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# EDITORIAL.

**The London Underground Railway.**—From an English engineer now traveling in this country, and who was before connected with the construction of this work, we learn several items of interest. Thus the engines employed are not, as is generally supposed, specially arranged for the suppression of smoke, etc.—in other words, of what is here known as the dummy pattern,—but are precisely of the usual form, with the exception of two points. In the first place, they are so arranged that the exhaust may be, at will, turned into the tank, in place of the chimney; and secondly, the furnace may be shut up air-tight at a moment's notice.

The plan of working them is as follows:—The road, we should premise, is not a continuous tunnel, but a series of alternate tunnels and open cuttings. In the open cutting the engines are run as on any other road; but as soon as a tunnel is reached, the exhaust is turned into the tank, the fire-box shut tight, and the engine run through by the accumulated heat in the furnace and boiler. The cost of this road, it may also be interesting to know, was about $4,000,000 per mile.

**Machine Packing.**—In selecting the best material for packing, it will be found very useful to bear in mind the following fact:—If the material used is itself impervious, only so much pressure need be applied as will cause it to fit tightly against the adjacent parts; but if the packing itself is porous, then a far greater pressure will be demanded, to bring its particles into close contact, and so render it impervious. This fact, we think, has much to do with the acknowledged superiority of rubber packing in certain cases.

**Fatal Explosion of an Oxygen Reservoir.**—An accident occurred a short time since, at the Pennsylvania Hospital for the Insane, in West Philadelphia, of which we shall here give a full account, because a knowledge of this is likely to prevent similar disasters in future. In this establishment, the Magic Lantern for more than twenty years, under the direction of Dr Kirkbride, Superintendent of the Institution, has been constantly employed, and has proved itself of incalculable service in connection with the neutral treatment pursued, affording as it does an inexhaustible supply of amusement, instruction, and mental occupation, without excitement. Long before the stereopticon was known to the public at large, lanterns for dissolving views and photographic projections, were familiar in that locality. Every improvement in the lanterns and their illumination, was promptly introduced, and for more than twelve years oxygen has been constantly made, and every night consumed, without accident or injury, until November 14th, when, during the manufacture of a fresh supply, the oxygen reservoir exploded, and a thick board used to support the weights placed upon it, striking the man employed in making the gas (who was close to it) on the forehead, fractured his skull. At the request of Dr. Kirkbride, we examined the apparatus, and think that the history of this accident may be briefly stated as follows:—The oxygen was made from chlorate of potash, without oxide of manganese, in a grinding machine, such as is figured and described in this Journal, vol. liii., page 58, the retort or pot, was heated in one of the ranges of the kitchen, on the ground-floor, the outlet pipe was connected, by a thick rubber hose (three-ply), with an iron tube passing through the floor, and leading into a tin gas-holder of the usual construction, in the cellar below. In this particular instance, the residue from a previous operation was, through carelessness or inadvertence, left in the retort, occupying probably about three-quarters of its capacity. When the retort was supposed to be hot enough, about a pound and a quarter of chlorate of potash was slowly ground in, but as there was no wash-bottle or other means of indication, the operator could not tell whether any of it was decomposed before the whole was introduced, and we think it extremely probable, that, owing to the residue in the retort, the whole charge was introduced before any gas had been liberated; in fact, when we examined the contents of the retort, we found a notable quantity of chlorate still remaining. Under these conditions, as all are aware, a large amount of chlorate would fuse, and then begin to liberate oxygen with violence, and it would be highly probable that sparks from dust or chips would be carried as far as the rubber tube, and ignited. We have, indeed, in our own experience, on three occasions, observed this very thing to happen when making oxygen from the materials placed in bulk in a retort. In those cases, however, the tube being thin, was instantly melted through; but in the present instance, the tube being very thick, and having an interlining of cloth, would resist for some time, and allow the white-hot flame of India rubber burning in oxygen to distill the interior rubber lining from the remainder of the tube, and drive it forward as inflammable gas into the reservoir. While this was going on, the man in charge of the process was on his way, by a somewhat circuitous staircase and passages, to the cellar below, to see how the reservoir stood; finding it less high than he expected, he probably lifted it, thinking it had stuck fast, and this relief of pressure caused the flow of gas to be more rapid, and thus carry fire into the reservoir, now containing the explosive mixture. The gas nowhere passed through water on its route. The rubber tube was found to be completely stripped of its interior lining, and burnt quite through at one point near the retort, which remained undisturbed on the fire, from which it was removed, by Dr. Jones, Assistant Medical Director, a short time after the explosion. The ultimate cause of this accident, we consider the absence of a wash-bottle in sight of the person managing the retort. With this adjunct, the grinding apparatus, in the hands of one possessing the most moderate intelligence, is absolutely safe, but without it, no process we have heard of is, with pure materials, more dangerous. With a wash-bottle in sight, a violent action resulting from an accumulation of material is impossible; for if each charge admitted is not at once decomposed, we are notified of the fact. Thus all risk of igniting the rubber tube is avoided, or, if it should occur, the smoke would at once show in the wash-bottle. The rubber tube might also be replaced by one of lead, but here a more serious danger is incurred in case of stoppage.

**The Camphor Storm Glass.**—Professor C. Tomlinson, Kings College, W. C., in a late letter to the editor of the *Chemical News*, alluded to a paper published by himself in the *Philosophical Magazine* for August, 1863, in which he proved, that the instrument above named owed its crystalline changes not to variations in moisture, barometric pressure, light, or electricity, but simply to those of heat, and adds certain new points, among which is this. By dipping a piece of filter paper in ether, and placing it on one of those glasses, a crystalline deposit may be determined to any part at pleasure, in a few seconds, and will conform to any pattern or device we may give the paper.

**Time of the Earth's rotation effected by the accumulation of Meteoric Matter.**—In a lecture delivered before the British Association at Dundee, Professor Alexander Herschel makes the following curious observation:—A question which at present agitates the minds of physical astronomers, is to ascertain whether a slight acceleration of the moon's apparent motion can be attributed to an error in calculation, or whether the earth in the course of ages has lost in its speed of rotation. The lunar tables, which exactly represent the moon's apparent motion at the present time, do not absolutely give the hour of an eclipse which happened when the sun was setting at Babylon, some hundred years B. C. The eclipse began, according to the table, when the sun was already below the horizon, and it would be invisible at Babylon. But if the earth's rotation had been a little more rapid in former times than at present, the sun, instead of having set, would have appeared eclipsed before his setting, as was indeed the fact. To account for this change in motion, the friction of the tides has been considered, a slow accumulation of meteorites upon the earth's surface would undoubtedly diminish its speed of rotation. The change of a hundredth part of a second in the length of the day, since the earliest observations, would explain the existing discrepancy.

**The Electric Spark—Space-penetrating power of its light.**—It was long since shown that the Leyden jar discharge produced a light of higher intensity even than that from the sun, though of course of enormously less volume. It would now appear that this intensity involves an equal power of penetrating space. In a late letter to the *Chemical News*, the Abbé Moigno tells us, that M. Felix Lucas has shown, that a spark yielding an actual light but $\frac{1}{2000}$th of a carcel wick (measured by the photometer employed by the Lighthouse Administration), showed a marked superiority over an electric (voltaic) light, equal to one hundred and twenty-five carcel lamps.

**Means of increasing the quantity of Electricity from Induction Coils.**—In the proceedings of the Royal Society, vol. xv., No. 84, just received, we find an admirable article by the Rev. T. R. Robinson, D.D., on the above subject. In this, the author first points out the value of an increase in the quantity of electricity developed by these machines, and then proceeds to discuss the various means by which this increase may be secured.

*First.* Increased power of the exciting battery; this, however, is open to two objections: injury to the acting surface of the contact breaker, and disproportionate minuteness of effect, beyond moderate limits, thus in certain experiments, 1000 of a unit repressing the product of the current, and number of spires, gave a result of 576 in one magnet, and 235 in another; another 1000 units adds to these effects 87 and 19, respectively; a third 1000 adds 35 and 8, and a fourth 1000 only 19 and 3.

*Secondly.* The outer helix may be made of longer or of thicker wire; here, however, we find that length gives no increase in quantity, while that obtained by thickness soon reaches a limit. We therefore come to the third and last method, by combining several coils collaterally, in a manner analogous to that in which galvanic cells are united for quantity.

The apparatus employed to produce and test these effects, was briefly, as follows: On an oaken table were fixed, vertically, four primary helices, their axes being 12 and 18 inches apart; two of these are 12½ inches high, having in four layers 383 and 343 spires, respectively; the other two are 13½ inches high, and have each, in two layers, 181 spires. The current normally is passed first through one of the last mentioned coils of 181 spires, is then divided between the first pair of 383–343 spires, and is finally passed through the remaining coil of 181 spires. Thus the exciting force (equal current × by number of spires) is about equal in each coil. A Fizeau's condenser is placed on a shelf below; though this is so important in producing sparks, it has very little effect on quantity, this being with it 1·000, without it 0·9948. This of course is with a continual circuit. These primaries are all thoroughly insulated with glass jars.

On these were supported, in various combinations, eight secondary helices of different length and thickness of wire.

Without entering into the detail of experiments, we will simply state the general result. First. Two helices in series give no increase of quantity, though their intensity nearly equals the sum. Second. The quantity of helices connected collaterally, equals the sum of their separate effects. Third. The quantity increases with the diameter of the wire, to a maximum reached when this is about $\frac{1}{65}$th of an inch. Fourth. Helices on different primaries combined, produce more effect than when on the same primary.

In combining various instruments, their helices may be extremely unequal without loss of effect; these primaries should not be consecutively connected if numerous, as the action of the current would then be very destructive to the circuit breaker. It would indeed be best to have separate batteries for each instrument, all the circuits being broken (as it is easy to arrange) by the same rheotome.

Induction coils are becoming common, and it would not therefore be difficult in many cases to collect several of them, and by combining them, obtain results, never before reached by any method, for the development of statical electricity.

**Steam Rollers for Roads.**—The employment of these machines in Paris has been noticed before in this *Journal*, and we would now mention that they are also receiving successful application in England.

Some time since Messrs. Easton, Amos and Anderson made a set of rollers for the new park of Mr. Hanbury, which were drawn by a traction engine built by Messrs. Averling & Porter; but in the course of operation, it was found that the effect produced by the wheels of the traction engine was as good as that of the roller, though the latter weighed fifteen tons. A traction engine, with wheels three feet broad, was therefore built and used for the purpose. A short time since, another of these engines, or rather steam rollers, was made for the borough of Liverpool, and on its trial, at Hyde Park, was found to operate in the most satisfactory manner. The wheels or rollers of this machine were seven feet in diameter, two feet six inches on the face, and weighed nine tons each.

**The Carbon Smee Battery.**—It is well known, no doubt, to most of our readers, that a platinized carbon plate may be substituted, with excellent effect, for the silver in Smee's Battery. In a letter received lately from C. T. Chester, of New York, we find the following practical evidence upon the subject: "I examined the Cooper Institute Battery, a few days since. It is six cells of carbon Smee, in nine-inch stone pots. It goes up and down by cords and pulleys. It gives a nine and a quarter-inch spark from the old Ruhmkorff, which is now practically its fullest extent. This battery, with about two charges of sulphuric acid and water, does all the amount of lighting up their hall by the spark and all the experiments during the course pertaining to the coil, as well as all of those shown to visitors from time to time for one year.

We are also doing a great deal here with the large flat carbon plates in Smee's batteries for electrotyping. All Harpers', and Tract and Bible House work is done by them.

**A Locomotive for Common Roads** has been patented in England, in which the tires are made of soft vulcanized india rubber. It is stated that this enables it to pass over ruts, cobble-stones, ploughed fields and grassy lanes with equal facility. One of these engines was lately constructed by Mr. R. W. Thompson, of Edinburgh, and on its trial was reported to behave in a most satisfactory manner.

**Les Mondes and M. l'Abbé Moigno.**—We notice with pleasure the great improvement that has shown itself in this journal, since it has been under the management of our friend and correspondent, M. l'Abbé Moigno, who for the last twenty years has indefatigably worked in the cause of science, both by his own researches and by his literary labors, in recording, and thus immortalizing, the works of others. As co-editor of the *Cosmos*, he for many years contributed largely to the support and reputation of that renowned journal.

For reasons which we will not here discuss, his connection with this publication has ceased, and he has since thrown all his energy into *Les Mondes*, which manifests conspicuously the scope and character of his genius, and does credit to his varied ability. The last numbers which we have received are full of interest, and replete with instruction. They contain numerous engravings of new apparatus, beautifully executed and accompanied by lucid explanations, notes of all scientific novelties generally, abstracts of the proceedings of learned societies, and interesting comments on the topics of the day.

**Carbonized Paper.**—We have, on a previous occasion, mentioned the invention designated as above, and made some months since by Mr. J. E. Hover, of this city, and we now again call attention to the fact, that at the last meeting of the Institute samples of all forms of writing paper, such as note and letter sheets of various sizes and envelopes, as well as varieties of printing paper, were exhibited, and thus the actual progress of the practical realization of Mr. Hover's plan was indicated.

The carbonized paper, as we have before remarked, is simply paper so charged with an earthy carbonate, that the ink, containing as it does sulphate of iron and gallic acid, reacts by formation of sulphate of the earth and the black per-gallate of iron, so that even if the ink is of the palest possible description, it becomes intensely black on contact with the paper.

In addition to this, the mineral sulphate formed acts as a mordant, attaching the ink more firmly to the paper, and also, by reason of the entire neutralization of the free acid of the ink, the risk of fading in the writing or decay of the paper is greatly diminished if not entirely removed.

The mineral matter employed in surfacing the paper has also a marked effect in preventing "greasiness," and in causing the ink to flow freely and pleasantly in writing.

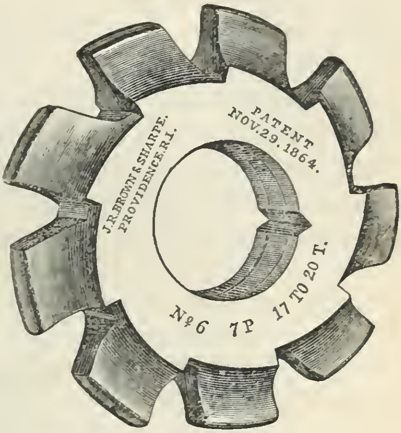
It is also stated, that, for a like reason, this paper will also take the printing-ink more readily, and furnish a blacker and smoother impression.

**The Suez Canal.**—By the last advices, we hear that a steam-tug, the English government vessel *Prompt*, has been actually floated through from the Mediterranean to the Red Sea.

She was lightened in every way possible, even to the removal of her side-wheels, and then, with the aid of sundry empty casks, at last "bumped" safely through.

**Specialties in Tool Making.**—Under this head, we discussed in our November issue, several improvements in cutting-tools and other instruments, and in our December number gave an abstract of an extensive article published in Engineering, bearing upon the same subject (p. 366). We now call attention with pleasure to another of the many existing improvements in *tools* used for the manufacture of *tools*, this being the *Cutters for Teeth of Gear Wheels*, by Brown & Sharpe, Providence, R. I. We give from the catalogue issued by this firm the following excellent description:—

While improvements have been made in almost every other tool in common use, there seems to have been no change for the better in the construction of cutters for the teeth of gear wheels, which, as every machinist knows, are troublesome and expensive to make and last but a short time, as they soon become dull and then require to be annealed, re-cut and hardened again, the cost of which is nearly equal to that of making new cutters, while the steel is liable to injury from repeated heating.


J.R. BROWN & SHARPE.
PROVIDENCE.R.I.
PATENT
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To overcome these difficulties, a cutter has been made, as shown in the engraving, by constructing the teeth or blades in the form of segments or curvilinear sections that are mechanically accurate in outline and of equal size and contour throughout their entire length, each of which has a sufficient circumferential inclination with respect to the revolving circumference of the cutter to produce the proper degree of clearance, so that the tooth may be sharpened by grinding away its face until its strength is permanently impaired, so that it will always present the same cutting contour, each new face and cutting edge produced by grinding being a fresh radial section of an equi-form tooth throughout its whole length.

A cutter made on this plan will outlast many of the old form, with the advantage of being always ready for use. If, as frequently happens, the cutter becomes dull before a wheel is completed, it can be taken out, sharpened, and returned to its place in a few moments, without any risk of altering the form of the teeth to be cut.

**A Bridge across the Lehigh River** has been constructed, connecting the towns of Bethlehem and South Bethlehem, and was opened to the public on Monday. It is one thousand and sixty feet long and thirty-four feet high from low water-mark, and extends across the railroad track of the Lehigh Valley and the Lehigh and the Susquehanna Railroad Companies, the Lehigh Canal, the Lehigh River, and Monocacy Creek. It is a great improvement, and will be generally used in preference to the old bridge, as all obstructions and dangers from crossing the several railroad tracks will be thereby avoided. Its cost was $60,000.

**Tunnel across the Sierra Nevadas.**—The great tunnel of the Central Pacific Railroad, at the summit of the Sierra Nevada Range, is opened. The track is being laid on the Eastern slope, a locomotive is already running in the Truckee Valley, and in a few days the road will have reached the open country of the Salt Lake Basin, after which progress will be rapid and easy. This overcomes the only noticeable obstacle on the western portion of the through line, and its significance is understood when we are told that the cost and difficulty of grading the 150 miles now nearly completed, is greater than for the 650 miles next following. The Chief Engineer expects to average a mile a day across the interior valley next year.

The local traffic on the completed portion surpasses all previous estimate, and is lucrative without the immense through business which we may expect to flow over it.

## Editorial Correspondence.

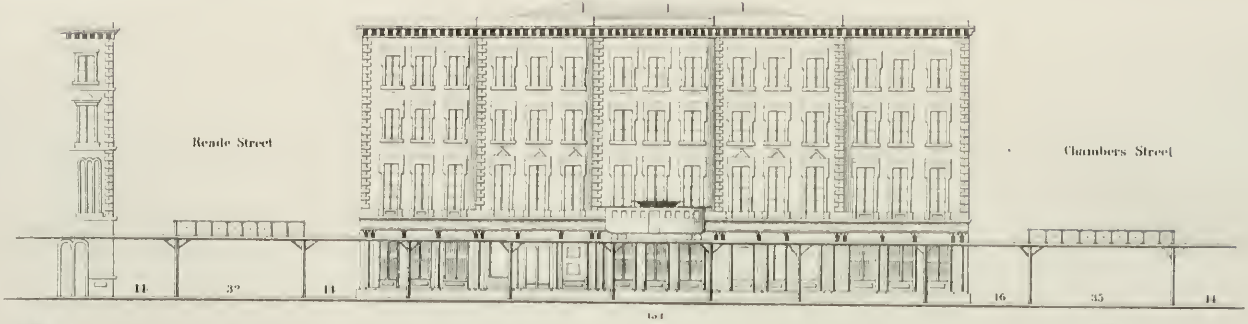
### WEST SIDE AND YONKERS ELEVATED PATENT RAILWAY.

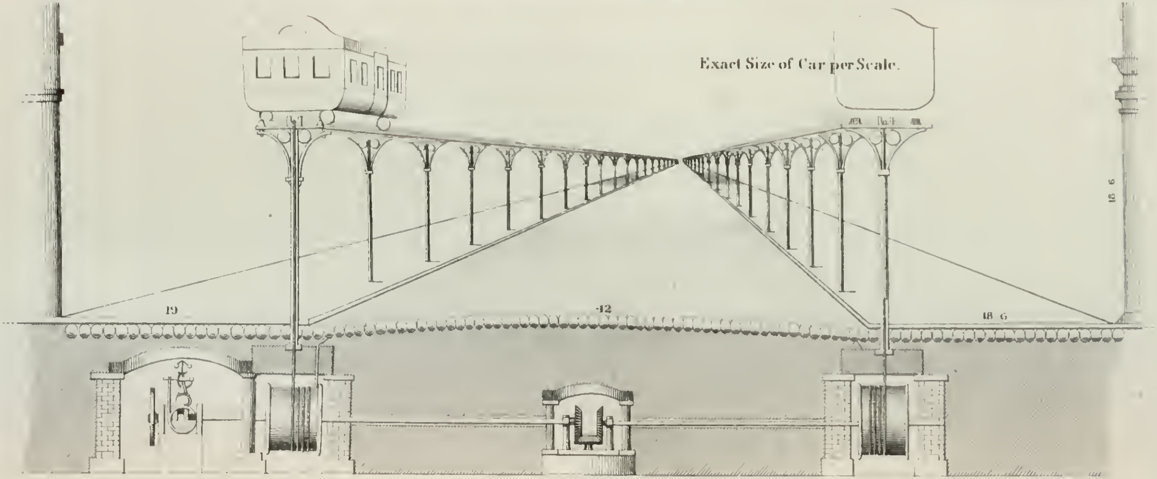
New York, *December*, 1867.

The experimental half mile authorized by act of Legislature last winter, is nearly completed, and its construction has become a matter of public observation. In obedience to my promise made some weeks back, I propose now to describe its design and method of working. The line starts corner of Greenwich street and the Battery, and is now finished up to Rector street, a distance of some 1500 feet. If the present experiment proves a success, the line will be continued this winter up Ninth avenue to the Hudson River Railroad depôt, corner of Thirtieth street, with the eventual idea of extension to the village of Yonkers, on the Hudson, *via* "King's Bridge." Should results warrant the further introduction of this system, a middle route up Broadway, as also an east side one as far as New Rochelle, on the Sound, are embodied in the schemes of the projectors.

The mode of construction is a very simple and elegant one, being unobstructive and open. The supporting principle, following the line of the curbstone, consist of *single* wrought iron columns, as made under the patent of the Phœnix Iron Company of Philadelphia, about fourteen feet high, with the segments spread out in a graceful curve, to which the cross-heads for supporting the rail-girders are attached. These are four-segment eight-inch columns,

## Elevation on Broadway.





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with a thickness of metal of three-eighths of an inch. This form, by the way, will be recognized from my October letter. They will be spaced twenty-five feet apart from centre to centre, as near as may, thus necessitating simple girders to span the interval. These girders are composed of eight-inch deck-beams in pairs, packed with a timber scantling, to which the rails are spiked, thus acting as an absorbent and cushion for the shocks of the traveling load. Beyond their fastening on the cross-heads of the columns, nothing more is required but simple stay-rods, to prevent the spreading of the rails and girders. The foundations are made stable by means of spreading out the segments at the base of the columns, in a similar manner as was noted above. A heavy casting, with necessary lugs and ribs upon it, is made to fit the under surface of the segments thus swelled out, to which they are securely bolted. This casting, by means of its broad, flat base, is in turn bolted to a very heavy under-casting secured to a well-bedded masonry pier ten feet deep, by means of long bolts running the whole length of the masonry, and firmly anchored therein. Between the rail-girders a small covered square trough, with a slot on its *upper* side, is placed, returning under the street in the axis of the roadway, and of course through the masonry piers, into which it is carefully built. This completes in the main what you may call, if you please, the inanimate construction.

*The motive* power will consist of stationary engines at *every* half mile under the side-walk, each one operating a large single drum six feet in diameter, ingeniously contrived to accommodate *two* ropes of contiguous sections. The sections being so short, steel-wire ropes of but one-half inch in diameter will be used, thus obviating what has always been considered an insurmountable difficulty. While on the subject of propulsion by an endless rope, it might be interesting, historically, to call attention to the fact, that English engineers and others had tried and given the system up as expensive and impracticable. It was adopted many years ago on the London and Blackwell Railway on a level track. Here a single rope was used in a length of several consecutive miles, requiring a diameter of something like five inches. A good speed was gotten up, but the clumsy character of the rope and the seeming impossibility of a satisfactory attachment and relief of the rope while in motion, caused an abandonment of the idea. In 1847 a plan was endorsed by the Mechanic's Institute, New York, of an endless belt elevated railway, and an experimental section was actually built encircling the Crystal Palace, but was destroyed by the same fire that brought that building to the ground. Most American engineers will remember Professor Gillespie's views on this style of railways, in his manual of "Roads and Railroads." In the line before us, the plan pursued, as above mentioned, requires a small rope, thus obviating one difficulty, the cars passing from one section to another by means of their own momentum. The gap thus caused is not over twenty feet, so that at a speed of say ten miles an hour, the resistance to progression must be inappreciably small. At proper intervals the rope will be attached to what you may call small "universal trucks" about two feet long—universal in the sense that in no matter what position they may be put, friction rollers will always be presented to roll upon. Upside down or sideways, they will roll, in addition to which, the attachment of the rope is by means of swivel-joints, so that no kink or twist can arise. A strong finger, as it were, projects above the slot mentioned in connection with the middle box in which it runs. To this the car is attached. The construction of the cars become, perhaps, the vital point in this scheme; but so far as competent engineering judgment can discern, no mechanical device has been neglected that promised to insure success. Experimenting alone will tell the tale, and to that end New Yorkers are looking with anxious interest. The difficulty is just here—a rope is running say at a speed of ten miles an hour, with nothing visible but the little fingers of the trucks—to these fingers the cars must be attached or detached, without slacking the rope and without producing a shock on the car or its passengers; it must slow up in stopping, and gradually get headway in starting. It would hardly do to jump at once at full speed; it would rack everything to pieces. The slowing up after detachment will be a matter easily regulated by brakes; but how to store up sufficient momentum to get under headway before making fast, is the *experimentum crucis* beyond which all other difficulties are but trifles. The first experimental car will be about 30 feet long, with a long barrel placed immediately below the floor, running the full length of car, surrounded with a stiff spiral spring. Secondary springs of india rubber are attached to the spiral spring and the body of the car, running in an oblique direction. The shock of contact will be taken up on the springs, which force is stored up by another set of springs, to be used in *starting* the car for the next station. Attached to the spiral, and sliding on the barrel, the immediate attachment is effected by means of a lever operated by the attendant in charge of the car.

Of course there must be an up and down track on either side of the way, with landing at proper intervals for passengers to get on or off. It is proposed to use the second floors of the buildings along the route, whenever needed, the entrances being the ordinary ones proper to any street building. The estimated cost is $250,000 per mile, which experience shows, on the portion now building, to be amply sufficient. The projector, patentee, and engineer is Mr. Chas. T. Harvey, whose plans have been faithfully executed by the Phœnix Iron Company, who can take an honest pride in their work as exhibited along Greenwich street.

I hope to be able to give at some future time full drawings, showing the mechanical devices of the scheme, but for the present merely illustrate this sketchy notice by means of a couple of diagrams showing the street appearance and the general arrangement of the motive power. Taken in connection with the text, I trust the principal features of this scheme will be made fully apparent.—A. P. B.

## CENTRAL RAIL LOCOMOTIVES.

*Professor Henry Morton.*

Dear Sir:—Will you allow me to correct a slight error, which I observe on page 320 of your November number? My friend Mr. Coleman Sellers is there stated to have made the following remark, when speaking about the centre-rail engine for railroads:—"The person to whom Professor Morton alluded was Mr. Trautwine, the Engineer of the Panama Railroad, who advocated the use of this plan across the isthmus. The engines were built; but the engineer who succeeded him concluded to cut down the road, and use common engines." The error consists in this: That I never contemplated the use of such engines on that road, further than as a temporary resort, while making the summit excavations; and even that idea originated with the board of directors, who were determined to leave nothing unprovided for that could expedite the work. I expressed to them the conviction that no such precaution was necessary; but inasmuch as it would at least do no harm, the directors requested their consulting engineer (Horatio Allen, Esq.,) and myself to witness some experiments with a large working model engine, prepared by Mr. George Escol Sellers, its inventor, and to report upon the result. We did so, and our report was unqualifiedly favorable, and the engines were accordingly ordered. This was at about the middle of 1850. They were not used on the Panama road, simply because, as I had predicted, no necessity for them presented itself; and my co-engineer and friend Col. Totten, who remained upon the road after I had resigned, employed them as common engines. A centre-rail engine had been patented in England in 1830 or 1831, by Errickson & Vignoles; but Mr. Sellers's engine combines self-acting means for adjusting the adhesion to suit both the grade and the load, with other peculiarities, which renders it so far superior to that of Errickson & Vignoles, that it must be regarded as essentially a new and original invention. About thirteen years since, as Engineer of the New York and Middle Coal Field Railroad, I recommended the use of the Sellers engine on a grade of 150 feet per mile; and the directors (the late city Postmaster, C. A. Walborn, Esq., President), notwithstanding the unfavorable opinions universally expressed by other engineers, and by locomotive builders, procured from Mr. Sellers two very powerful ones. Financial troubles, however, led to an abandonment of the road, and the engines were sold at very low prices to other coal companies. As none of the officers of these companies understood the principle or mode of action of the engines, they did not even make a trial of their capabilities, although it might have been done, and the grand problem satisfactorily demonstrated to all, for a few hundred dollars. As the worthy president of one of the companies himself complacently informed me, "We are all practical men on this road, and don't believe in thy gimcracks." The centre-rail machinery was accordingly taken off and melted up for castings; and thus Mr. George Escol Sellers was deprived of the honor of having his name associated with the first practical success of this invention—an honor ascribed to the inventor of the very inferior machine which is now daily hauling trains across the Alps. The day may perhaps come when the Sellers engine will in like manner cross the Rocky Mountains. In these few lines you have the entire history of the centre-rail engine in this country.

Yours, truly,

JOHN C. TRAUTWINE.

Philadelphia, Dec. 6, 1867.

# Civil and Mechanical Engineering.

## ON THE TRANSMISSION OF FORCE BY BELTS AND PULLEYS.

There are few mechanical engineers who have not been frequently in want of tabular information or readily applicable formulæ, upon which they could place reliance, giving the power which, under given conditions and velocity, is transmitted by belts without unusual strain or wear. The formula of the belt or brake is well known and simple, and it is only necessary to acknowledge and adopt a value for the co-efficient of friction (or of adhesion, which is perhaps the better term), to allow this formula to be applied in daily use. And this co-efficient of friction has been carefully established by the experiments of General Morin and M. Prony, and has been made available to English and American engineers, by the translation of Bennett.*

With every point needed, therefore, at the command of the engineer, it is somewhat surprising that a more extensive publication and general use of the data has not followed.

But notwithstanding the existence of this correct mathematical and experimental information, the numerous tables which have been given by mechanical engineers appear to have had only that kind of practical basis which has come from guessing that an engine or a machine, either the driving or the driven, with a belt of given width, was producing or requiring some quantity of power which might be expressed in terms (foot-pounds) generally without any stated arc of contact. Three rules given by practical mechanics, vary so much as to give as bases for estimate (without regard to arc of contact) 0·76 horse-power, 0·93 horse-power, and 1·75 horse-power, respectively, for the power of a belt one inch wide running 1000 feet per minute.

It was the requirement to know the exact useful effect of a novel disposition involving an unusual small arc of contact of the belt upon the pulley, where much embarrassment would result if the application proved itself unsatisfactory that led to the present inquiry. As the writer was not able to give the time demanded for making such experiments as would establish the practical co-efficient of adhesion, he suggested what was desired to Mr. H. R. Towne, and the numerous experiments, of which he gives the accompanying report, are the result of his labor and care.

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* Bennett's *Morin's Mechanics*, New York, 1860.

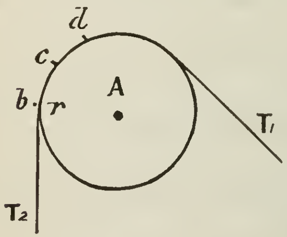
It must be remarked that there are some mistakes in the text of Bennett's translation, which will lead to serious errors, unless read by a careful investigator.

It was not until after the experiments were completed, that either Mr. Towne or the writer knew of the publication of M. Prony or General Morin, although Bennett's translation rested upon the shelves of the writer's library; but aside from the gratification which we feel at the corroboration, we think the reader of this article will be pleased to know that our data is founded upon the ordinary pulleys and belts of the workshop, and our experiments were not impaired by any niceties which common workmen would not apply.

Even the crudeness of our experimental apparatus and the general not over exact method adopted, will serve to demonstrate to the minds of practical men the possibility of relying upon figures which have been established so nearly in accordance with the customs of the workshop.

We take from Rankine's *Applied Mechanics* the following formula of a belt, only changing the words in the hope to make it comprehensible to the general reader in an elementary way.

Let A be a pulley upon which the belt passes from $T_2$ to $T_1$. Let $r=$ the length of radius of the pulley A. Let $T_1=$the tension of the belt (or the strain) on the tight side. Let $T_2=$the tension of the belt (or the resistance on the loose side). Then the pull on the belt by which it transmits power$=P=T_1-T_2$, and this difference represents the adhesion or friction resulting from the contact between the belt and the pulley.



If we suppose the tension on a unit of width of belt at $b=T_2$, then it follows that the normal pressure per unit of surface at the point $b=\frac{T_2}{r}$. The units of dimension, either linear or superficial, may be inches and square inches, feet and square feet, metres and metres square, or any other units of relative value. Thus we may say the normal pressure upon a square inch of surface at $b$, equals the tension on an inch-wide belt $T_2$, divided by the length in inches of the radius $r$.

We will endeavor to make this understood by comparing the case with the well-known instance of the relation of pressure to tension in the shell of a cylindrical boiler. If we take an example of a boiler having 10 inches radius (or 20 inches diameter) and with an internal uniform pressure of 100 pounds per square inch, it will be recognized that the tangential strain per inch of length of shell will be equal to the pressure multiplied by the radius, or 1000 pounds; and this tangential strain is uniform at all points of the circumference.

The tension $T_2$, in like manner, corresponds to the tangential strain just stated, and the resulting normal pressure corresponds to the internal uniform pressure. And as in the instance of the boiler the tangential strain is exerted at all points of the circumference, so the normal pressure proceeding from the tension in the case of a belt, is independent of the length of arc of contact on the belt, and refers to the point of contact $b$, wherever that point may be taken on the pulley.

Admitting, therefore, that the pressure at the point $b = \frac{T_2}{r}$, we have the friction resulting from the contact of the belt on a unit of surface $= f\frac{T_2}{r}$ (when $f$ is the co-efficient of friction of the leather of the belt on the pulley. This gives a new value for the tension of the belt at some point, $c$ (very near $b$), (or tangential strain at that point), $= T_2 + f\frac{T_2}{r} = T_2\left(1 + f\frac{1}{r}\right)$. And it follows that the pressure at $c = \frac{T_2}{r}\left(1 + f\frac{1}{r}\right)$, and the friction resulting from the contact of the belt on a unit of surface $= f\left[\frac{T_2}{r}\left(1 + f\frac{1}{r}\right)\right]$ This again gives a new value for the tension of the belt at some point, $d$ (very near $c$) $= T_2 + f\left[\frac{T_2}{r}\left(1 + f\frac{1}{r}\right)\right] = T_2\left(1 + f\frac{1}{r}\right)^2$ On taking further points in succession until we take $l$ points and reach the point $m$ on the figure, we have for the tension at $m = T_2\left(1 + f\frac{1}{r}\right) = T_1 \therefore \frac{T_1}{T_2} = \left(1 + f\frac{1}{r}\right)^l$

This equation is the well-known one of the hyperbolic logarithm. Where hyperbolic logarithm $\frac{T_1}{T_2} = f\frac{l}{r}$ or $\frac{T_1}{T_2} = e^{f\frac{l}{r}}$, where $e$ is the base of hyperbolic logarithms. We can further transform this equation by substituting the ratio of the angle in degrees, for the length of contact on the arc, compared to the radius.

$$\text{Thus } \frac{2r\pi}{360} = \text{arc of } 1^\circ, \text{ let } l = a\left(\frac{2r\pi}{360}\right) \therefore \frac{T_1}{T_2} = e^{f\frac{2\pi a}{360}},$$

and taking the numerical values of $e$, $\pi$, and dividing out the 360,

$$\therefore \frac{T_1}{T_2} = 2{\cdot}718^{0{\cdot}017456\, fa}$$

$$\therefore \log.\left(\frac{T_1}{T_2}\right) = 0{\cdot}4343\ (0{\cdot}017456\, fa), \qquad (1.)$$

$$\therefore \log.\ T_1 - \log.\ T_2 = 0{\cdot}00758\, fa$$

$$\therefore \frac{T_1}{T_2} = 10.^{\,0{\cdot}00758\, fa}, \qquad (2.)$$

$$\therefore f = \frac{\log.\left(\frac{T_1}{T_2}\right)}{0{\cdot}00758\, a} \qquad (3.)$$

As we assumed before, $P = T_1 - T_2$. $\therefore T_2 = T_1 - P$, which inserting in equation 2.

$$\therefore \frac{T_1}{T_1 - P} = 10^{\,0{\cdot}00758\, fa}$$

$$\therefore P\left(10^{\,0{\cdot}00758\, fa}\right) = T_1\left(10^{\,0{\cdot}00758\, fa}\right) - T_1$$

$$\therefore P = T_1\left(1 - 10^{-0{\cdot}00758\, fa}\right) \qquad (4.)$$

The third equation is the one to which we would now call attention. By it, for any given values for the ratio $\frac{T_1}{T_2}$, we can determine the co-efficient of friction, when, by experiment, we have fixed the greatest difference of the two strains without slipping on a pulley with a given arc (measured by $a$) of contact.

We would here make a very important observation, which forms the key of the whole system of transmission of force by belts. In practice, *all belts are worked at the maximum co-efficient of friction.* A belt may, when new or newly tightened, work under heavy strain and with a small co-efficient of friction called into action; but in process of time it becomes loose, and it is never tightened again until the effort to perform its task is greater than the value of the co-efficient with a given tension of belt, and the belt slips. We run our belts as slack as possible, so long as they continue to drive.

It has been shown[*] that the value of $T_1 + T_2$, or the sum of the strains upon the two sides of a belt (loose and tight), is a constant quantity—that is, when a belt is performing work, it will become loose on the one side to the exact amount that it is strained on the other, and when at rest, not transmitting force, the tensions will become equal, and their sum be the same as before. It is manifest that the limit of the strength of a belt is found in the maximum tension $T_1$, and that this strength being known, the effective pull ($P$) is further limited with any given arc of contact by the value $f$ of the co-efficient of friction.

The discussion has so far been limited to the pull exerted by a belt; when we would include the power which belts will transmit, we have only to multiply the pull by some given or assumed velocity, to transform our equations into work performed.

By means of the third equation, we will now deduce a value for the co-efficient of friction as given by the experiments.

All the experiments were with the arc of contact $= 180° = a$,

$$\text{which, substituting } f = \frac{\log. \frac{T_1}{T_2}}{1{\cdot}3644}$$

and the result of 168 separate experiments has given, under tensions of $T$, from 7 to 110 pounds per inch of width of belt, $\frac{T_1}{T_2} = 6{\cdot}294$.

$$\therefore f = \frac{\log. 6{\cdot}294}{1{\cdot}3644} = 0{\cdot}5833.^{\dagger}$$

In this case $T_1$ has in all cases been so much in excess of $T_2$, as to slip the belt at a defined, slow but not accelerating, motion.

From an examination of the report of the experiments, we think the reader will coincide with our conclusion that $\frac{6}{10}$ of this value of $\frac{T_1}{T_2}$ can be taken as a suitable basis for the working friction or adhesion which will cover the contingencies of condition of the atmosphere as regards temperature and moisture; or

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[*] Bennett's Morin, page 303, and following ¶ 252.

[†] Bennett's Morin, page 306, ¶ 253, gives $f = 0{\cdot}573$.

$\frac{T_1}{T_2}=3{\cdot}7764$ (maximum practical value) $\therefore f=\frac{\log.\,3{\cdot}776}{1{\cdot}3644}=0{\cdot}42292$.[*]

The experiments further show that 200 pounds per inch of width of belt is the maximum strength of the weakest part—that is, of the lace holes. Taking this, with a factor of safety at one-third, we have the working strength of the belt, or the practical value for $T_1$ $=66\frac{2}{3}$ pounds.[†] The case when belts are spliced instead of laced, a great increase of strength has been shown, the experiments giving 380 pounds per inch of width, or 125 pounds safe working strength.

If we insert these values of $f$ and $T_1$ in (4,)

$$\therefore P=66\tfrac{2}{3}\left(1-10^{-0{\cdot}0078\times0{\cdot}42292\,a}\right)$$

$$\ddagger\ \therefore P=66\tfrac{2}{3}\left(1-10^{-0{\cdot}003206\,a}\right) \qquad (5.)$$

The largest possible angle for an open belt, without a carrier or tightener, is 180°, as upon either the driving or the driven pulley

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[*] It should be noted that the experiments were made without any appreciable velocity of belt, and throughout this paper no regard has been paid to the effect of velocity or of the dimensions of the pulleys upon the value of the co-efficient of friction.

For pulleys less than 12 inches diameter (with the belts of the ordinary thickness of about $\frac{3}{16}$ths inch), and for velocities exceeding about 1000 feet per minute, allowance must be made for the rigidity of the belt in the one case, and for the *interposition of air between the pulley and the belt* in the other. At high speeds, say 3000 feet velocity of belt per minute, the want of contact can be seen, sometimes, to the extent of one-third the arc encompassed by the belt. The writer has proposed to place a deflector or stripper near the belt, to take off the stratum of air moving with it, but has never tried the experiment, although he has little doubt of its giving some advantage.

[†] Bennett's Morin, page 306, ¶ 253, gives 55·1 pounds per inch of width as admissible.

[‡] This equation (5,) is the really important one in practice, and by means of logarithms, can be solved for any values of $a°$ readily; but as some of those who may wish to use it may not be at once prepared to use the logarithmic notation, from want of use or practice, we give an example. Suppose we take an angle of 90°, the negative exponent then becomes $-0{\cdot}003206\times90=-0{\cdot}28854$; subtracting this from 1, we have $-1{\cdot}71146$. This term thus becomes $10^{-1{\cdot}71146}$. Now this expression is only the notation for anti-logarithm $-1{\cdot}71146$, or in words the number for which $-1{\cdot}71146$ is the logarithm. Logarithmic tables give this number $=0{\cdot}51505$, and the equation $P=66\frac{2}{3}\left(1-10^{-0{\cdot}003206\times90}\right)=66\frac{2}{3}\left(1-10^{-1{\cdot}71146}\right)=66\frac{2}{3}$ $(1-0{\cdot}51505)=66\frac{2}{3}\times0{\cdot}48495$.

$$\therefore P=32{\cdot}33$$

this cannot be exceeded, but for crossed, or carried, or tightened belts, the angle may be as large as 270°.

We give the following table of results for different arcs of contact (corresponding to $a°$) within the usual limits of practice.

TABLE I.

*Strain transmitted by belts of one inch width, upon pulleys when the arcs of contact vary as the angles of*

| 90° | 100° | 110° | 120° | 135° | 150° | 180° | 210° | 240° | 270° |
|---|---|---|---|---|---|---|---|---|---|
| Pounds. | Pounds. | Pounds. | Pounds. | Pounds. | Pounds. | Pounds. | Pounds. | Pounds. | Pounds. |
| 32·33 | 34·80 | 37·07 | 39·18 | 42·06 | 44·64 | 49·01 | 52·52 | 55·33 | 57·58 |

If we suppose the pulley to be 1 foot in diameter, and to run some number, N, of revolution per minute, we have the power transmitted $= N \pi P$.

And we give the following table for different arcs of contact (corresponding to $a°$) within the usual limits of practice.

TABLE II.

*Power transmitted by belts on pulleys one foot in diameter one revolution per minute. Arcs of contact of belts upon pulleys corresponding to the angles.*

| INCHES OF WIDTH OF BELT. | 90° | 100° | 110° | 120° | 135° | 150° | 180° | 210° | 240° | 270° |
|---|---|---|---|---|---|---|---|---|---|---|
| | Foot-lbs. | Foot-lbs. | Foot-lbs. | Foot-lbs. | Foot-lbs | Foot-lbs. | Foot-lbs. | Foot-lbs. | Foot-lbs. | Foot-lbs. |
| 1 | 102 | 109 | 116 | 123 | 132 | 140 | 154 | 165 | 174 | 181 |
| 2 | 203 | 219 | 233 | 246 | 264 | 280 | 308 | 330 | 348 | 361 |
| 3 | 305 | 328 | 349 | 369 | 396 | 420 | 462 | 495 | 521 | 542 |
| 4 | 406 | 437 | 466 | 492 | 528 | 560 | 616 | 660 | 695 | 723 |
| 5 | 508 | 547 | 582 | 615 | 660 | 701 | 770 | 825 | 869 | 904 |
| 6 | 609 | 656 | 699 | 738 | 792 | 841 | 924 | 990 | 1043 | 1084 |
| 7 | 711 | 766 | 815 | 861 | 924 | 982 | 1078 | 1155 | 1217 | 1265 |
| 8 | 813 | 875 | 932 | 985 | 1056 | 1122 | 1232 | 1320 | 1391 | 1446 |
| 9 | 914 | 984 | 1048 | 1108 | 1188 | 1262 | 1386 | 1485 | 1564 | 1626 |
| 10 | 1016 | 1094 | 1165 | 1231 | 1321 | 1402 | 1540 | 1650 | 1738 | 1807 |

The application of Table II. to any given cases of known angle of the arc of contact, width of belt in inches, diameter of pulley in feet, and number of revolutions, is simply to take the figures from the table for the first two, and multiply by the two succeeding conditions, to obtain the foot-pounds of power transmitted.

We have taken the following examples:—First. Mr. Schenck (of New York) found an 18-inch wide belt running 2000 feet per minute, the pulleys being 16 feet to 6 feet, would give 40 horse-power, with ample margin (one-fourth). (*Sic.*)

If we take the distance from centre of the 16-feet pulley to that of the 6-feet to be 25 feet (about the usual way of placing the fly-wheel pulley of an engine in regard to the main line of shafting), we have the arc of contact subtending about 153°. From Table I. the strain transmissible is 45·1 pounds × 18 × 2000 = 1,623,600 foot-pounds = 49·2 horse-power.

Second. Mr. William B. Le Van (of Philadelphia) found by indicator that an 18-inch wide belt running 1800 revolutions per minute, the pulleys being 16 feet and 5 feet, respectively, transmitted 43 horse-power, with maximum power transmissible unknown. If we take the centre's distance, as before, at 25 feet, we have the arc of contact subtending about 150°.

From Table I. we derive 44·64 pounds as the strain transmissible × 18 × 1800 = 1,446,336 foot-pounds = 43·83 horse-power. The same authority found by indicator that a 7-inch wide belt over two 2-feet 6-inch pulleys, 11 feet centre to centre (horizontal), moving 942 feet per minute, gave 8 horse-power. From Table I. for 180° angle, we take 49·01 × 7 × 942 = 323,172 foot-pounds = 9·79 horse-power. This belt was stated to be very tight.

Third. Mr. A. Alexander (*London Engineer*, March 30th, 1860) gives a rule that a 1-inch belt will, at 1000 feet velocity, transmit $1\frac{3}{4}$ horse-power.

If we take the contact at 180° from Table I., 49·01 × 1000 = 49,000 foot-pounds, we have only $1\frac{1}{2}$ horse-power.

Fourth. Mr. William Barbour (same journal, March 23, 1860) gives as the power a 1-inch belt will transmit with 1000 feet velocity = 0·927 HP., when we derive with 180° angle from our tables = $1\frac{1}{2}$ HP.

Fifth. A. B. Ex (same journal, April 6, 1860) gives a rule

$$\frac{\text{diameter in inches} \times \text{revolutions per minute} \times \text{breadth in inches}}{5000}$$

= N HP. ratio of pulleys not to exceed 5 to 1. Changing this rule to

$$\frac{\text{diameter in feet} \times \text{revolutions per minute} \times \text{width in inches}}{5000 \div 12 \div 33{,}000} = \text{N foot-}$$

pounds.

$\therefore \dfrac{\text{Diameter in feet} \times \text{revolutions per minute} \times \text{width in inches}}{0{\cdot}01263} = x$ foot-pounds.

$\therefore 79{\cdot}2 \times$ diameter in feet $\times$ revolutions per minute $\times$ width in inches $= x$ foot-pounds.

From Table II. the angle of 120° gives 123 in place of 79·2, and it would appear this authority adopts about $\frac{2}{3}$ the effect we take.

Sixth. Dr. Fairbairn gives (*Mills and Mill Work*, Part II., page 4) a table of approximate width of leather straps in inches necessary to transmit any number of horses-power, the velocity of the belt being taken at 25 to 30 feet per second (1500 to 1800 per minute), 1 foot pulley, 3·6 inches wide, gives 1 HP.

Assume 1650 feet per minute, contact 180°, we have from Table I., $1650 \times 49{\cdot}01 \times 3{\cdot}6 \times 1 = 29{,}112$ foot-pounds $= 0{\cdot}87$ HP.

Seventh. Rankine gives (*Rules and Tables*, page 241) 0·15 as the co-efficient of friction, probably applicable to the adhesion of belts on pulleys to be used with his formulæ in estimating the power transmitted. Neither experiments nor practice give so small a co-efficient as this.

We could multiply authorities on these points, but think the corroboration of those we quote with our tables, sufficient to establish our experimental and estimated co-efficient of friction, $f = 0{\cdot}423$, as a proper practical basis.

We give the two following cases not only to show the application of the formula 5, but as matters of some interest.

In the construction of one of the forms of centrifugal machines for removing water from saturated substances, the main or basket spindle is driven by cone-formed pulleys, one of which, being covered with leather, impels the other by simple contact.

In the particular instance taken, the iron pulley on the spindle was 6 inches largest diameter, and the leather-covered driving pulley was 12 inches largest diameter—the length of cones on the face was 4 inches, this last dimension corresponding to width of belt in other cases. By covering the leathered pulley with red lead, we were able to procure an *impression* on the iron pulley, showing the width of the surfaces of contact when the pulleys were compressed together with the force generally applied when the machine was at work. This width was, at the largest diameters, almost exactly $\frac{1}{4}$ an inch. From the nature of the two convex surfaces compressing the leather between them, the actual surface of efficient contact cannot be taken at over half this width (the slight error in estimating this contact as straight lines in place of circular arcs may be neglected). This gives the angle subtended by the arc of contact on the iron pulley = 2½°, taking equation (5). $\text{P} = 66\tfrac{2}{3}\left(1 - 10^{-0{\cdot}003206\,a^{\circ}}\right) = 66\tfrac{2}{3}\left(1 - 10^{-0{\cdot}008015}\right) = 66\tfrac{2}{3}\left(1 - 10^{-1{\cdot}991985}\right) = 66\tfrac{2}{3}\left(1 - 0{\cdot}98171\right) = 66\tfrac{2}{3}\,(0{\cdot}01829) = 1{\cdot}3717.$

Now, the average diameter of the iron pulley in the middle of its 4-inch face is 4·708 inches = 0·3923 feet, with a circumference of 1·2326 feet, and it is usual to run, at the least velocity, 1000° revolutions per minute; whence the power given by these pulleys = 1·3717 pounds × 4 inches × 1·2326 feet × 1000 revolutions = 6757 foot-pounds = ⅕ HP. As the work performed by one of these centrifugal machines is the acquirement of velocity under the resistance of the friction of the machine and of the air, and the work of expelling the moisture is so insignificant in comparison that it may be neglected in estimating, it can be taken as probable that the real power demanded to keep the machine in motion is very nearly that given by calculation. It should be stated that the basket belonging to this particular machine is 29 inches diameter and 12 inches deep.

The second special case we instance at present, consists in a proposed arrangement for driving a fan which had previously been found to demand an 8-inch belt on a 10-inch pulley to run it 1275 revolutions per minute. (The arc of contact here was 162°, so that the apparent power, with a very tight belt, was 37½ HP.; but about ⅓ of this was defective adhesion from running a rigid belt over so small a pulley.) It was thought desirable to avoid the fast-running countershafts, and drive this direct from an engine-pulley fly-wheel, by impingement, so to speak, of the belt on its tight side between the fan-pulley and another larger carrier pulley, against a portion of the periphery of the fly-wheel.

If we suppose the force demanded measured on the fan-pulley as before, to be 40 HP. = 1,320,000, and the fan-pulley to be 10 inches diameter × 16 inches wide, and to run 1250 revolutions per minute;

$\therefore \dfrac{1{,}320{,}000}{1250 \times \frac{10}{12} \times 16 \times \pi} = 25{\cdot}2$ as the pull, P, on each inch of width of the belt as it comes from the 10-inch pulley. By substituting this value for P in equation (5), and then reducing the equation to find the value for $\alpha°$, we have $\alpha°=65°$, which is the angle of contact demanded to give the necessary adhesion.

It will be noticed that this angle is independent of the diameter of the fly-wheel pulley, it being only requisite that that diameter should be such as with the given or assumed number of revolutions will produce the given velocity. In the case taken for example, the fly-wheel pulley was 16 feet diameter × 16 inches wide, with 70 revolutions per minute velocity.

As we have before remarked, the sum of the two tensions on the belt is constant, whether the belt is performing work or not;

that is, $S=T_2+T_1$; but $P=T_2—T_1$. $\therefore T_2=T_1—P$. $\therefore S=2T_1—P$. As we assumed in equation (5) T to equal $66\frac{2}{3}$ pounds, we can substitute the value of P as in Table I. in the equation, $S=2\ (66\frac{2}{3})—P=133\frac{1}{3}—P$, from which it is evident that the sum of the tensions will vary with P or with the angle of contact. It is evident, also, that the load upon the shaft proceeding from the tensions $T_2$ and $T_1$ will be the resultant of whatever angle the belt makes with a line joining the centres of the two pulleys, or as the cosine of that angle.

By constructing on paper a pair of pulleys, it will be readily discerned that the angle in question for small pulleys $=90°\ \frac{\alpha}{2}$, and for large and crossed ones, $=\frac{\alpha}{2}—90°$, we can consequently form the following table:—

TABLE III.

STRENGTH OF LACING OF JOINT $66\frac{2}{3}$ POUNDS PER INCH WIDE,

*Showing, first, the sum of tensions on both sides of a belt, per inch of width, whether in motion or at rest, when strained to transmit the maximum quantity of power in general practice; and showing, second, the load carried by the shafts and supported constantly by the journals per inch of width of belt, when the arcs of contact vary as the angles of*

| | 90° | 100° | 110° | 120° | 135° | 150° | 180° | 210° | 240° | 270° |
|---|---|---|---|---|---|---|---|---|---|---|
| | lbs. | lbs. | lbs. | lbs. | lbs. | lbs. | lbs. | lbs. | lbs. | lbs. |
| 1st, | 101· | 98·53 | 96·26 | 94·15 | 91·27 | 88·69 | 84·32 | 80·81 | 78· | 75·75 |
| 2d, | 71·42 | 75·47 | 78·85 | 81·53 | 84·32 | 85·67 | 84·32 | 78·05 | 67·59 | 53·56 |

When machinery is driven by gearing, the shafts only carry the running wheels and the weight, and when the machines are thrown on, the friction of the lines increases with the work; but with belts and pulleys the load on the line and its frictional resistance is constant, whether the machinery works or lies idle.

Of course, it is not proper to assume that the load produced by the belt on the shaft is exactly that given by the second line in Table III.; but we can be safe in taking those weights as rarely exceeded, because belts begin to fail when they are; and as rarely much less, because few of our machines are not worked up to their belt capacity.

The advantages shown by the figures on all the tables, but especially on the last, in those arcs of contact over 180° where crossed belts are used, have the substantial ground of practice, although many mechanics are unaware of the facts. The writer will instance a case of several heavy grindstones having from main to counter lines eight-inch crossed belts on pulleys three feet diameter, running 120 revolutions, only eight feet centre to centre, where belts have already lasted, day and night use, three and a half years. For the same purpose, six-inch open belts were formerly used with an average duration of a few weeks only.

Another use of a crossed belt is for long belts, the crossing effectually preventing those waves which generally impair, if they do not destroy such belts when open.

Besides the actual power transmitted by belts, which it has here been attempted to embrace in a general law, the application of belting, both the manner and the purpose opens a field for discussion far beyond the limits of the present article. The writer, hoping that others will take up the subject, so that the published data of the mechanic may more fully include the practice of the workshop and factory.

## AN ACCOUNT OF THE FILLING OF A SINK-HOLE.

By Charles Paine, C.E.

At a marsh about one mile east of Lawrence, upon the "air-line" of the Michigan Southern and Northern Indiana R.R., there occurred, during the construction of the line, a sinking of the embankment which had been nearly completed across the marsh, the fibrous superstratum, of from six to eight feet in thickness, having broken off at each side of the bank, letting the whole drop into a lake of semi-fluid peat below. Efforts at filling up the hole were continued for a long time; but making very little show for the amount of material absorbed, the work was finally abandoned, the track having been carried around the edge of the marsh by very sharp reversed curves. The inconvenience of this interruption of the straight line, and the destruction of rails on these curves, became considerable, as the traffic of the road increased, and it was thought very desirable to complete the embankment across the marsh. Upon sounding, the peat-bed or lake was found to be about forty feet deep, or from grade about forty-five feet to hard bottom, for a distance of about thirteen hundred feet;—where the embankment had once been built the soundings were only from ten (10) to twenty (20) feet below grade; but at two places, two hundred and three hundred feet long, respectively, no filling had been done.

As the only earth to be procured in the vicinity was a clay which would stand in water at a comparatively low angle, it was evident that an earth bank would require a large quantity, even where a core had already been formed by the work previously done, to complete the slopes. I therefore determined, for that portion of the bank under water, to use materials always at hand upon railways, viz: the decayed sleepers removed from the track in the course of repairs.

The height of grade above the water being five feet, a platform thirty-five feet in width would carry an embankment fourteen feet wide at grade, leaving a leerme three feet wide at each foot of the slopes; such a platform was accordingly laid down and then built upon, each course sinking those below it, until the bottom was reached, the succeeding layers crossing each other, the sleepers also breaking joints longitudinally and alternately, so as to bind the whole together as firmly as possible, keeping the outer edges of the platform somewhat higher than the middle, so as to give the outside sticks a tendency towards the centre.

This work was begun during the winter of 1865–6, and completed during the next winter, at times when the working-train could best be spared for such labor, the earth filling and ballasting having been done during the past summer. Some difficulty was experienced from the slow settling of the platform through the peat, at the points where no earth embankments had previously been made, as the bank which was first made upon the sleepers sunk the platform too far below water, where the earth had to be removed and the platform raised with additional courses of sleepers; but the whole appears now to have reached the bottom. The trains have been running over the new line for about two months, and the settling is not greater than upon any new embankment. The economy of this mode of forming the bank will be seen to have been considerable, the estimated cost of an earth bank having exceeded $30,000, while the cost of this construction has amounted to not quite one-third of that sum.

## BRIDGE OVER THE ALLEGHANY.

THE bridge of the Pittsburgh, Fort Wayne and Chicago Railroad over the Alleghany River, is now completed. An interesting account of its construction we extract from the *Pittsburgh Gazette*:—

The magnificent iron bridge over the Alleghany River, which has been under course of erection by the Pittsburgh, Fort Wayne and Chicago Railway Company for some time past, has been completed, and our city can now boast of two of the finest and most substantial viaducts in the country. The new structure is a most important one, forming as it does a permanent connecting link for one of the greatest highways of travel and trade centering in this city, and, in regard to the manner of its construction, the materials used, and the difficulties which had to be surmounted in prosecuting the work, may be looked upon as a triumph of engineering skill.

The following comprehensive description of the bridge, for which we are indebted to T. D. Messler, Esq., and other officials of the company, will be read with interest.

The bridge which formerly crossed the river at the point occupied by the new bridge, was originally built by the Ohio and Pennsylvania Railroad Company, to complete their connection with the Pennsylvania Railroad at Pittsburgh. The foundations were begun in the month of August, 1854, and the bridge finished in September, 1857, by the Pittsburgh, Fort Wayne and Chicago Railroad Company, of which the Ohio and Pennsylvania Railroad was one of the consolidated companies.

The original superstructure for double track was of wood, on the Howe truss plan, with arches for additional strength. The increased traffic on the railway, and with it the larger wear and tear occasioned, in addition to the bridge not being properly protected in the first years after its erection, made it a necessity at a very early day (considering the importance as a main line of trade and travel between the East and West, which the Fort Wayne Railway had acquired) to provide for its reconstruction.

In the fall of the year 1863, the then Chief Engineer of the Railway Company, John B. Jervis, Esq., after careful examination, submitted and recommended for approval of the President, George W. Cass, Esq., the present plan, an entirely wrought iron structure, designed and calculated in regard to strength in all its details by Felician Slataper, Engineer and Architect of the company, under whose immediate superintendence the work has been executed.

The plan having, during the following winter, been adopted, a contract was made with Charles J. Schultz, of Pittsburgh, for the construction of its iron work, which was commenced in the spring of the year 1864.

The original structure consisted of seven spans of various lengths, being in all 1172 feet long. On account of the peculiar form and location of the company's freight yard at Pittsburgh, between the bridge and Penn street, it was found necessary to place the switches, that connect the large number of tracks in their yard, as far as possible out on the bridge, in order to use the ground in the most economical and advantageous manner, and to facilitate the lengthening of these tracks for the contemplated new and large freight houses required for the better accommodation of the constantly increasing business of the Railway Company.

To accomplish this, an additional pier 101 feet long was built on the wharf, under the first span on the Pittsburgh side, and the abutment extended parallel with the river, along Duquesne Way, to 148 feet in length. By this arrangement the bridge as now constructed, opens gradually like a fan towards the Pittsburgh freight yard, being at the narrowest part, next to the main span, 55 feet in width, and extending out for 176 feet in length, to the point where it connects with the yard, where the width is 138 feet.

The surface thus gained being equivalent to nearly two-fifths of an acre of additional ground, is covered over between the rails with three-inch oak plank fastened on the solid oak floor beams of the bridge, which are placed 18 inches apart.

For symmetry and economy in the construction, another pier was also built on the wharf at the Alleghany city end span of the bridge.

At both of these end spans the tracks are now supported from below by strong iron plate girders, made entirely of plate and angle iron, all well riveted and substantially braced together.

The two western spans have each three girders 89 feet in length and 6 feet 6 inches deep, to support the double line of railway, the middle one being made proportionately stronger. On the two eastern spans, which form the above-mentioned addition to the yard, eighteen iron plate girders, varying in length from 86 to 93 feet, all 6 feet 1 inch deep, are placed, distributed according to the tracks they are intended to spuport.

The five large spans over the main part of the Alleghany River are built for a double line of railway, with one projecting foot-path on the outside, consisting of three main girders, one on each side and one in the centre, between the ways.

The average length of the spans is 153½ feet in the clear, with a bearing of 5 feet on each pier.

The depth of the girders is 19 feet. The clear width between the outside and the central girders is 14 feet, except the south part of the first main span, where it widens from 14 feet at one end to 32 feet at the other.

The top and bottom sections of the girders are in the form of the letter T, but they, as well as all other parts, are carefully arranged so as to insure, as much as possible, uniform strength for the bridge throughout, in proportion to the effects produced upon it by the load. The cross-sectional area of the top chord consists of four thicknesses of iron laid one over the other, well riveted, and forming together a plate 2¾ inches thick and 24 inches wide in the centre part of the girder, and diminishing gradually to about two-thirds its cross-section at the ends, where it rests on the piers. In addition to which there are two large angle-irons 5 inches by 3½ inches by ⅞ inch to ½ inch thick, and two vertical bars 12 inches by ½ inch on the inside between the angle-iron, running along the centre of the horizontal plates which form the top and bottom portion of the girders, to which they are attached by two of the angle-irons, the other two serving to join the flanges to the bars, which form the vertical web.

The cross-sectioned area of the bottom chords consist of three thicknesses of iron, well riveted, forming together a plate, in the centre part 2¼ inches thick and 27 inches wide, the balance of the construction being similar to the top chord.

The vertical web is composed of lattice work, which is framed with two sets of bars six inches wide, crossing each other and inclined to the top and bottom at an angle of 48°, and forming a net-work, the distance of the crossing apart being 2 feet 1 inch between the centres of the rivets, measured along the bars, the thicknesses of the bars increasing from $\frac{1}{4}$ inch at the centre part to $\frac{5}{8}$ inch at the ends of the girders. They are secured at their crossings by two rivets. The lattice work is stiffened by vertical angle-irons fixed double on both sides, at distances of about 8 feet apart.

The central girder has about $\frac{1}{3}$ more iron in the cross-section than the outside girders.

All the iron work is well braced and tied together above and below, by a system of transverse and diagonal rods.

The ways inside, to insure proper elasticity, are supported by white oak floor-beams, at intervals of 2 feet apart between centres, on which the steel rails for the railway are fastened.

The following amount of iron was used in the twenty-four plate girders of the end spans, including bracing, tie-rods, &c.

| | Pounds. |
|---|---:|
| Plate iron | 540,900 |
| Bar iron | 69,800 |
| T and angle iron | 142,600 |
| Rivets | 45,400 |
| Cast iron bed plates | 49,300 |
| Total | 848,000 |

The five main spans of lattice girders contain:—

| | Pounds. |
|---|---:|
| Plate iron | 1,190,600 |
| Bar iron | 592,100 |
| T and angle iron | 718,600 |
| Rivets | 133,000 |
| Cast iron bed plates | 73,700 |
| Total | 2,708,000 |

Over 350,000 rivets (each of which was required to be made red hot before they were driven home in their respective places) were used to connect together the above-described 1778 tons of iron.

The cost of the iron bridge superstructure proper, was $435,000.

The total cost, including additional masonry, temporary support of tracks, and other incidental expenses, $530,000.

The iron, of a superior quality, has been purchased for the whole structure, from Messrs. Jones & Laughlin, of the American Iron Works of this city.

The principle of the construction is known as the latticed-girder plan with vertical stiffenings, and the structure is believed to be the only one of the kind in the United States, although the principle is used very extensively in modified forms on the German, Russian, and Italian railways.

## TESTING STEAM-BOILERS.

By S. W. Robinson,

Assistant Professor of Mining Engineering and Geodesy, University of Michigan.

It is generally believed that steam-boilers become weakened, for resistance to internal pressure, after continued use, from various known and unknown causes; so that the engineer cannot judge of the pressure to which his boiler can be worked with safety. But this he may determine by a very simple process, and means which are always at his command. It is as follows:—Let the boiler be filled entirely full of cold water, even to the throttle and safety-valves, and all closed tight to prevent any escape. Now, by lighting a fire under the boiler, the water will be gradually expanded, and produce a pressure sufficient even to rupture the iron before the temperature of the water arrives at the boiling point. While the pressure is increasing, let the steam-gauge or pressure indicator be watched; and when the test pressure, which may be twice or more times as great as the working pressure, is reached, a portion of the water may be allowed to escape and the pressure reduced. The pressure results from the fact that water is expanded more by heat than iron. The process above given is attended with as much safety as the use of the hydrostatic press, unless the water be heated above 212°, which would not be required unless the boiler leaks. Below this temperature no disastrous consequences would follow, even if the boiler should be torn asunder, inasmuch as explosions result from the sudden expansion of gases or vapors.

Ann Arbor, Michigan, December 9th, 1867.

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The Wilmington and Reading Railroad, which is to be built during the present year, starts from Wilmington and runs over the high grounds on the west side of the Brandywine, entering the valley of that stream ten miles from Wilmington, at Twaddle's Ford, and follows the west branch of the Brandywine through Coatesville, and crossing over the East Brandywine near Isabella Furnace, thence by Springfield and Jones's Mines down the valley of Hay Creek to the Philadelphia and Reading Railroad, at Birdsboro'. The length of the road will be fifty-five miles, and estimated cost $1,664,000.

# Mechanics, Physics and Chemistry.

## LECTURE-NOTES ON PHYSICS.

By Prof. Alfred M. Mayer, Ph.D.

(Continued from vol. liv., page 329.)

### § II. *Instruments used in Precise Measurements.*

A law of Physics, as we have seen, consists in the general relation which exists between the numbers which are the final results of our observations and experiments; and therefore, the first subject to be discussed in the exposition of that process by which we arrive at a law, is the description of those *instruments* which have given such minute precision in the numerical determinations of modern Physicists.

The *instruments of precision* used in making the measures required by the Physicist may be arranged under the five following divisions:—

1. Instruments used to measure . . *Lengths.*
2. " " " . . *Angles.*
3. " " " . . *Volumes.*
4. " " " . . *Weight.*
5. " " " . . *Time.*

### *Instruments used to measure Lengths—Dividing Engines.*

*Standards of Length.* Before commencing a measurement of length, the error of the unit we use should be accurately determined by comparison with a government standard, or with a well authenticated copy.

Two units of length are used in this country: *the yard* (subdivided into feet, inches, and tenths of inches), and *the mètre* (subdivided into tenths, hundredths, thousandths, and so on decimally).

*The yard*, originally derived about 1120, from the length of King Henry the First's arm, was accurately *fixed* by Captain Kater, in 1818, when he obtained the ratio of the length of the *standard English yard* to the length of a pendulum beating seconds (*i. e.* making 86,400 vibrations in one mean *solar* day) *in vacuo* at the level of the sea, in the latitude of Greenwich. He found that the length of such a pendulum, from the point of suspension to the centre of oscillation, was 39·13929 inches.

The actual standard of length of the United States is a brass scale of 82 inches in length, prepared for the U. S. Coast Survey, by Troughton of London; meant to be identical with the English Imperial Standard, and deposited in the Office of Weights and Measures at Washington. The temperature at which it is a standard is 62° Fahr., and the yard measure is the length between the 27th and the 63d inches of the scale. (See "Report on the Construction and Distribution of Weights and Measures," by Dr. A. D. Bache. 1857.)

Two copies of the new British standard, viz: a bronze standard, No. 11, and a malleable iron standard, No. 57, have been presented by the British Government to the United States. A series of careful comparisons, made in 1856, by Mr. Saxton, under the direction of Dr. Bache, of the British bronze standard, No. 11, with the Troughton scale of 82 inches, showed that *the British bronze standard yard is shorter than the American yard by* 0·00087 *inch.* So that, in very exact measures with the yard-unit, it is necessary to state whether the standard is of England or of the United States.

"*The Mêtre* is a standard bar of platina, made by Lenoir in Paris, which has its normal length at the temperature of zero centigrade, or the freezing point. Its length is intended to make it a *natural* standard, and to represent *the ten millionth part* of the terrestrial arc comprised between the equator and the pole, or of a quarter of the meridian. The length of this arc, given by the measurement, ordered for the purpose by the Assemblée Nationale, of the arc of the meridian between Barcelona, through France to Dunkirk (about $9\frac{1}{2}$ degrees), combined with the measurements previously made in Peru and Lapland, gave for the distance of the equator from the pole 5,130,740 *toises.* The standard toise was made in 1735, in Paris, by Langlois, under the direction of Godin. It is a bar of iron which has its standard of length at the temperature of 13° Reaumur. It is known as the Toise du Pérou, because it was used by the French academicians Bouguer and La Condamine in their measurement of an arc of the meridian of Peru. The toise of Peru = 2·13145 English standard yards. They found an ellipticity of $\frac{1}{334}$, and the length of the mêtre 443·29596 lines of the toise du Pérou, assumed to be 443·296 lines or 3 feet 11·296 lines. This last quantity was declared in 1799 to be the length of the *legal mêtre*, and *vrai et définitif*, and is the length of Lenoir's platina standard. Later and more extensive measurements in various parts of the globe, however, seem to indicate that this quantity is somewhat too small. The latest and most exact results we now possess, combined and computed by Bessel, would make the quarter of the meridian 10,000,856 mètres, and the mètre =443·29979 Paris lines. Schmidt's computation would make it 443·29977 lines, and both numbers are confirmed by Airy's results. The legal mètre is thus, in fact, as Dove remarks, *a legalized part of the toise du Pérou*, and this last remains the *primitive standard.* But it must be added that a natural standard, in the absolute sense of the word, is a utopian one, which ever-changing nature never will give us. The mètre is, for all practical purposes, what it was intended to be, a natural standard; though it must be confessed that, in practice, the question is not whether and how far a standard is a natural or a conventional one, but how readily accurately it can be obtained, or recovered when lost." (See A. Guyot's Tables, Meteorological and Physical, p. 111.) Captain Kater in 1818 determined with great care the value of the *mètre* at a temperature of 32° Fahr., in inches of Shuckburgh's copy of the standard yard (made by Troughton) at 62° Fahr., and found one mètre at 32° Fahr.; =39·37079 inches at 62° Fahr. Therefore the quadrant of the *French* meridian contains 393,707,900 English standard inches.

It has recently been shown by M. Schubert that the equator of the earth is not a great circle, but an ellipse: having its major axis =41,854,800 feet, and its minor axis=41,850,007 feet, giving an ellipticity of $\frac{1}{8850}$th. From this it necessarily follows that different quadrants of the earth will differ, being longer when passing near the major axis than when passing in the neighborhood of the minor axis. Consequently, the mètre is only the $\frac{1}{10000000}$th part of the quadrant passing through Dunkirk. Sir John Herschel computes 4008 feet for the excess of the true quadrant over that assumed as the basis of the metrical system; which makes the French standard $\frac{1}{208}$th of an inch too short.

Sir John Herschel proposes for the British standard an aliquot part of the *polar axis* of the earth, as a natural unit, and shows that by increasing the existing British standard yard (and with it of course its subdivisions) by exactly the $\frac{1}{1000}$th part of its present length, the polar axis will contain 500,500,000 of inches each $\frac{1}{1000}$th longer than the present standard inch. Herschel also shows, that by adopting this new value of a foot, that one cubic foot of distilled water at 62° Fahr. will contain 1000 ounces if we increase the present ounce only the $\frac{1}{15}$th of a grain; and thus there will exist a simple relation between the measures of length and of weight. (See Familiar

Lectures on Scientific Subjects, Article, "The Yard, Pendulum, and Mêtre," by Sir John Herschel. A. Strahan: London and New York, 1866.)

In 1866, Congress passed an act directing that 15 grammes of the metric system of weights shall be deemed, and be taken for U. S. postal purposes, as the equivalent of one-half ounce avoirdupois.

The new U. S. five-cent piece is made 2 centimetres in diameter, and weighs 5 grammes.

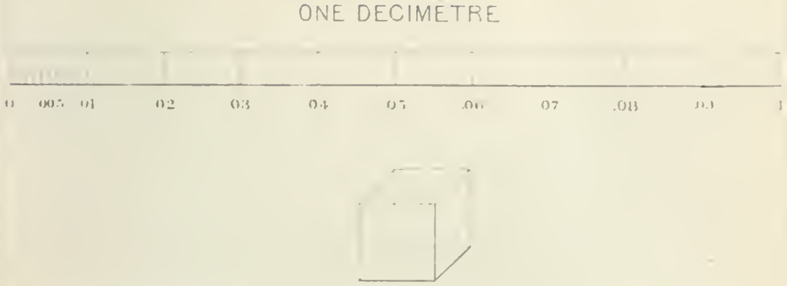
See plate I. for the French measure of one decimetre, divided into centimetres and millimetres; and the English measure of four inches divided into halves and tenths.

(The standards of one yard and of one mêtre exhibited.)

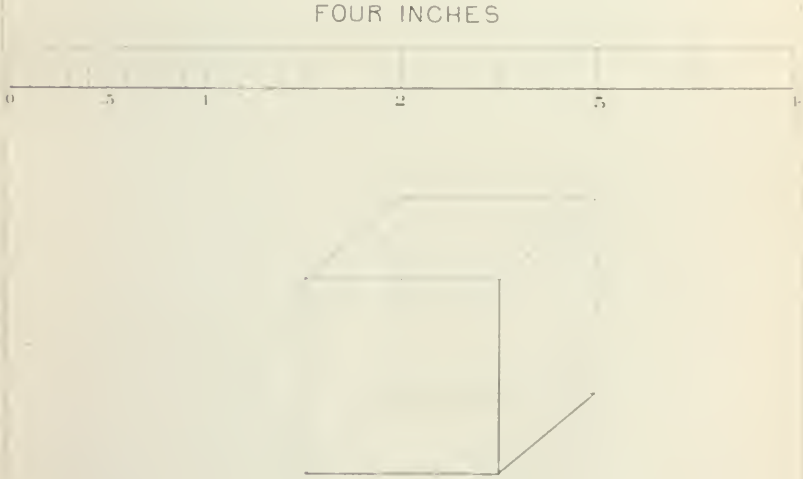
*Measurement of lines of considerable length.* There are two modes of directly measuring lines of considerable length. The first consists in placing in *contact* the ends of rods having an exact standard length, and thus applying these units to the line whose length is required. The second consists in bringing the beginning of one unit to coincide with the end of another, by *bisecting* a fine × mark near the end of one of the rods by the cross-threads in a microscope attached to the end of the other rod. The distance on a rod between the cross-hairs in the microscope at one end and the × mark at the other being equal to a standard length.

With the precise apparatus of the U. S. Coast Survey, a base of ten miles can be measured so accurately that the error made is only about $\pm \frac{1}{10}$th of an inch. (See U. S. Coast Survey Report for 1854, p. 103, *et seq.*, for a description of this apparatus for measuring base-lines.)

*The Vernier* is a device for subdividing still further the lowest divisions of a scale without dividing directly those divisions by equidistant lines. It consists of a *sliding* scale called the *vernier*, which glides along the length of the main scale, and has on it divisions which *differ* from those of the main scale by a known fraction of the smallest subdivision on the main scale. Thus, suppose we have a main scale of inches divided into tenths, and we wish to divide the tenths of inches into ten parts by a vernier, thus giving us the hundredths of inches: we take a length of *nine-tenths* from the main scale, and place it on the vernier, and we divide this length into *ten* equal parts, which necessarily gives divisions on the vernier, each of which is $\frac{1}{100}$th of an inch less than the smallest division of tenths on the main scale; therefore, by seeing where a line of the vernier corresponds with a



One Cubic Centimetre of Distilled Water at 4° C = 1 Gramme



One Cubic Inch of Water at 62° F = 252.456 Grains

line on the main scale, the next following lines of the two scales are distant from each other $\frac{1}{100}$th of an inch; the next following lines differ $\frac{2}{100}$ths, and so on; and thus we can subdivide any $\frac{1}{10}$th of an inch of the main scale into hundredths of an inch.

In general, to read to the $n$th part of a scale division, $n$ divisions of the vernier must equal $n + 1$ or $n - 1$ divisions on the main scale, according as these run in opposite or in similar directions.

Large models exhibited of vernier applied to straight line and to arcs of circles.

*Rule* for finding the smallest reading by means of the vernier. *Divide the value of the smallest divisions on the main scale by the number of divisions on the vernier.*

This beautiful and very useful invention is due to Pierre Vernier, of France, who first described it in a work entitled "La construction, l' usage et les propriétés du cadran nouveau." Bruxelles, 1631.

*The Cathetometer* (from Gr. Κάθετος vertical height, and μέτρον a measure), consists of a vertical rod, which rotates round its axis, and carries a telescope, provided with a spirit-level, whose line of collimation is at right-angles to the axis of the rod. The rod rests on a base furnished with levelling screws and spirit-levels, so that it can be brought into a truly vertical position. The telescope is attached to a vernier plate, which slides along the length of the rod which is divided into fractions of the mêtre or of the foot. The instrument is used to measure the vertical distance between two points, whether on the same vertical line or not. It is of constant use in making all measures of vertical distances.

(Instrument exhibited, and method of using it shown.)

This instrument was invented by Dulong and Petit, and subsequently improved by Pouillet.

*Micrometer Screw* (from Gr. μικρος small, and μέτρον a measure) consists of a screw with a large circular head, whose circumference is divided into a certain number of equal parts. Suppose the screw has 50 threads to the inch, and that its circular plate, which rotates with it, is divided into 200 parts; then if the screw is turned a whole revolution, it will advance, in the block in which it turns, $\frac{1}{50}$th of an inch; but if the head is revolved only through $\frac{1}{200}$th of a revolution, the screw will advance the $\frac{1}{10000}$th of an inch. With a good micrometer screw we can measure accurately the $\frac{1}{1000}$th of a millimetre, or about the $\frac{4}{100000}$th of an inch.

(Large model exhibited, also the instrument itself in various forms.)

*Spherometer.* As its name indicates, it is used to measure spheres; or, more concisely, to determine the radius of any spherical surface, as, for instance, the radius of the surface of a glass lens. It was invented by the optician de Laroue, for the latter determination. It consists in a micrometer screw, supported vertically by a tripod. The points of the feet of the tripod are equally distant from each other; and they, as well as the screw, terminate in fine nicely rounded extremities. The point of the screw and the points of the tripod are brought into the same plane by placing the instrument on the truly plane surface of a slightly roughened glass plate, and bringing the screw's point to bear on the plane with the same degree of pressure as the points of the tripod. This is attained by means of a jointed lever, which moves with the screw, and its shorter arm bearing on the glass, its longer arm is always brought into the same position. This can only be clearly understood by examining the instrument. The instrument is now removed to the lens, the radius of whose curvature we desire, and the point of the screw brought down upon the glass till it bears with the same degree of pressure as in the previous instance. The difference of readings on the head of the micrometer screw gives the perpendicular distance of the point of the screw above the plane passing through the points of the feet of the tripod; or, in other words, the height of a segment of a sphere, having for radius the radius of curvature of the lens, and for base the circumscribed circle of the equilateral triangle made by the points of the three feet of the spherometer.

Calling this height $h$, the radius of the circle passing through the feet of the tripod $r$, and the radius of the spherical surface of the lens R, we have

$$2\,\mathrm{R} - h : r :: r : h; \quad \text{whence}$$
$$2\,\mathrm{R}\,h - h^2 = r^2; \quad \text{therefore}$$
$$2\,\mathrm{R} = \frac{r^2 + h^2}{h},$$

half the value of 2 R being of course the radius of curvature of the lens.

The spherometer will give accurate measures to the $\frac{1}{1000}$th of a millimetre, and is so minute in its measurements, that if the finger be momentarily placed on the plate of glass under the point of the screw, and we again bring down the screw to this portion of the glass, we find that the heat from the finger has swelled the glass at the part touched into a protuberance!

It is easy to see how this instrument is also used for measuring the thickness of plates.

*Comparator.* Model of instrument exhibited and described. Invented by Lenoir in 1800, to compare standards of length.

In this instrument, as well as in the following one, we measure a multiple of the quantity we wish to estimate.

*Saxton's Reflecting Comparator and Pyrometer.* Model of this instrument exhibited, and mode of using it shown.

It is so delicate that it will measure with precision the $\frac{1}{100000}$th of an inch.

"This very ingenious instrument has been applied to comparing the yard of the kind called *end-measure*, in which the distance between the two ends of the bar is the length of the standard yard. One end of the bar to be compared abuts against a fixed support, the other end is free to move, the whole bar being supported horizontally on rollers. The free end presses against a small horizontal bar or slide, connected by a chain, with a vertical axis, carrying a small mirror. As the free end of the bar moves, the slide moves also, and turns the mirror. A scale placed horizontally at any convenient distance from the bar and in the same general direction, is reflected in the mirror, the image being viewed by a telescope placed at the same distance as the scale, and directly over it. The distance of the reflected image of the scale being twice that of the scale from the mirror, the motion of the mirror is shown as on a divided circle of that radius, and the smallest movement of the mirror is measurable."

(See "Report by Dr. A. D. Bache, to the Secretary of the Treasury, on the Construction and Distribution of Weights and Measures," Washington, 1857, p. 15, *et seq.*)

The illustrious Gauss, of Göttingen, first used this method of reflection in his measures of the forces of terrestrial magnetism.

It also can be applied to the galvanometer, by attaching its needles to a very light silvered mirror; and thus the smallest motions of the needles can be shown to the largest audience.

*Dividing Engines.* To divide the straight line into fractional parts, and the circumference of the circle into degrees, minutes, and seconds, machines are used which, when made with care and used with skill, are capable of working with great precision.

*To divide the straight line.* The simplest apparatus for dividing the straight line is that described by Bunsen in his "Gasometry" (London, 1857). The rod, tube, &c., to be divided is placed in a line with a standard scale, and with long, rigid beam-dividers, having one of its points on a division of the scale we describe, with the other point a line on the rod &c. to be divided; we then move the point of the dividers to the next division of the scale, describe with the other point another line on the rod, and so on.

If the weight of the dividers is partly supported by a cord, passing over a pulley overhead, and attached to a weight, and an assistant, with a glass, carefully places the point on a division of the scale while the operator describes the line, this method will give an accurate copy of the scale from which we transfer the divisions.

The most accurate machine for dividing the straight line consists of a plate placed on Λ shaped guides, and moved in the direction of its length by a screw attached to its lower side. The rod &c. to be divided is clamped to the upper surface of the plate, and a cutting tool, which can only move in one and the same plane perpendicular to the length of the plate, cuts the divisions on the rod after each rotation of the screw. If the screw contains ten threads to the centimetre, then at each whole revolution of the screw the plate will advance one millimetre; and any fraction of a millimetre can be cut by rotating the screw that same fraction of a whole revolution.

So minute is the accuracy of which this machine is susceptible, that it is able to cut 75,000 equidistant and parallel lines in the breadth of an inch, and each division is distinctly visible under the highest power of the microscope. A still greater number, probably over 100,000 lines, can be cut in the length of an inch, but they cannot be discerned even by the highest powers of the best microscopes, furnished with the most perfect means of illumination. In this case our mechanical exceeds our optical power.

A graduated series of these lines, increasing in the number to the inch, are used under the name of Nobert's test lines, to determine the defining power of the objectives of microscopes.

Another example of fine engine work is given in "Barton's buttons," which are gold buttons stamped with a hard steel die on which Barton cut hexagonal groups of fine equidistant lines with a diamond. On account of the interference produced in the light reflected from the surface of these buttons, they flash with the brilliancy and the colors of gems.

From the above description of the performance of the dividing engine, it is easy to see how, having fine lines cut at known intervals apart on plates of glass, and placed in the ocular or on the stage of a microscope, we have the means of measuring distances which surpass in minuteness the determinations of the micrometer-screw.

*To divide the circumference of the circle.* Two methods are used in the graduation of the circumferences of the circles of astronomical and other instruments.

In the first, and probably the most accurate method, the circle to be divided is centered and clamped upon a large *accurately* graduated circular plate, which revolves on a vertical axis, and under a cutting tool which moves only in one and the same vertical plane passing through the centre of the circle. The divisions on the periphery of the large and *originally divided* circle are successively bisected by the cross-wires in the ocular of a fixed microscope, by revolving the plate under the microscope by means of a tangent screw; and at each bisection the tool cuts a line in the border of the circle to be graduated.

In the other method a tangent screw works in the notched edge of a circular plate; and by one whole revolution of the screw the plate is carried round 10′. After each revolution the tool cuts the division. Thus the circle is divided into arcs of 10′ and into smaller fractions of a degree if desired.

The first method is used in Germany; the second, invented by Ramsden, and subsequently improved by Troughton & Sims, and by Gambey, of Paris, is practiced in England and in this country. At the U. S. Coast Survey Office in Washington, can be seen a very superior dividing engine, made by Troughton & Sims, of London.

In both methods the circle of the engine has originally to be divided by the principle of bisection. To bisect a straight line, one point of a beam-compass is placed at one extremity of the line, while with the other point we strike a fine line nearly bisecting the line we wish to divide. From the other extremity of the line an arc is struck with the same radius, and the minute space included between the lines thus formed is bisected with a fine needle-point under a microscope. A scale of equal parts is thus formed with the most extreme care; and having attached to it an accurate vernier, we take in the beam-compass from this scale a length which exactly equals the chord of an arc of 85° 20′ of the circle to be graduated, and with this chord we strike on the circle an arc of 85° 20′. By continued bisections this arc is subdivided into equal parts of 5′ each. The 60° division can be obtained by a chord equal to the radius of the circle, and this arc of 60° bisected gives 30°, which, added to previous arc of 60°, gives an arc of 90°.

The reader is referred to an article on "Graduation," by the celebrated artist Troughton, in the *Edinburgh Encyclopedia*, for the best account extant of this, the most delicate and difficult problem of mechanical art; which has tested to the utmost the combined skill of the first mechanicians, and of the ablest astronomers of modern times.

(To be continued.)

## MANUFACTURE OF BEET-ROOT SUGAR IN THE UNITED STATES.

By John Birkbeck.

Feeling a deep interest in all that relates to the successful progress of American industry, the writer was induced, during a late trip to the West, to make a visit to the Beet-root plantation and sugar manufactory established at Chatsworth, Illinois.

Chatsworth is a village of some 800 inhabitants, located in Livingston County, on the line of the Toledo, Peoria and Warsaw Railway. The direction of this railway is east and west, connecting at Gilman, fifteen miles east of Chatsworth, with the Chicago branch of the Illinois Central Railway, at Chenoa, twenty-two miles west, with the Chicago, St. Louis and Alton Railway, and at El Passo, thirty-seven miles west, with the main line of the Illinois Central Railway.

This location is on the prairie land; the marked feature of the country being its level surface, unbroken by either hills or trees of any size. The greater part of the land is uncultivated, and is covered with prairie grass.

The plantation and works of the Germania Sugar Co. are located at the south-east corner of the village. They have 2500 acres of land, 550 of which have been planted this year with the sugar-beet, and the balance with corn, oats and hay.

The refinery is located near the railway track, and consists of main buildings of wood, which contain the machinery proper, and several other frame buildings, used as storehouses and stables.

The enterprise was started some four years since by the brothers Gennert of New York, but has since been made a stock company, the members of which are all residents of the West.

The planting is done in April, and the beets harvested in October, at which time the manufacturing commences, and continues until March. On harvesting, the beets are piled in trenches in the fields for protection from the frosts, enough being taken each day to supply the working capacity of the refinery. The machinery was transported from Germany, and has a capacity for working sixty tons of beets in twenty-four hours.

The first process is the washing of the beets, and for that purpose is used a cylindrical vessel four feet diameter by ten feet long, its circumference or shell made of wooden slats placed longitudinally, with alternate openings between them. This drum is placed at an angle of 10°, both ends are open, the beets thrown into the higher end, and the drum slowly revolved by appropriate gearing in a water-tank of sufficient depth to bring the water-line midway between the axis and lower edge of drum. The interior of the drum is provided with a spiral screw and angle-pieces, which give the beets a continual movement through the water towards the lower end, the earthy matter being washed off and passing through the openings between the slats into the tank below. The beets are discharged from the lower end on a revolving table some twelve feet in diameter, around which are placed women and boys, who remove all the diseased and defective ones, and prune off all the useless parts. The perfect beets are thrown into the buckets of an elevator near at hand, and discharged into a hopper on the floor above, which delivers them to two rasping or pulping machines. These machines are simple, and consist of revolving drums about two feet diameter by two feet long, the circumference being provided with projecting saw-blades set at a slight angle with their axis, the blades being parallel with each other, and about two inches apart. The drums are revolved with great rapidity inside of close cases, and water to the amount of ten per cent. of the weight of the beets is introduced continuously during the operation. The discharge is a fine pulp, delivered into a traveling bucket, in front of ten centrifugal draining machines, which are placed on an intermediate floor midway between the first and second floors.

The charge for each centrifugal is 200 pounds of pulp, in which twenty pounds of water has been added during the rasping process, making 220 pounds in all. The centrifugal drum is then revolved some 1500 revolutions per minute, thirty-five per cent. additional water being introduced during the process.

The juice evolved in the operation is conducted from the centrifugals by canals to a line of six deficators, each of 300 gallons capacity, while the dry pulp is removed from the interior of the drum for the use of the cattle as fodder.

The deficating process is the same as pursued with sugar cane juice, excepting that an excessive quantity of lime is used for neutralizing the acids.

Below each deficator is an upright cylindrical vessel made of wrought iron plate, of about 600 gallons capacity. These vessels are provided with heating worms at their bottoms, and covers with hinges on top. The clear juice of each deficator is discharged into the corresponding vessel below it.

The scum arising from the defication is subjected to the action of scum presses, by which the syrup remaining is made available.

The lime employed in the defication is removed by the action of carbonic acid gas, which is forced into the liquor while in the vessels below the deficators, by means of a steam-pump. The gas is manufactured in a lime kiln, on the premises.

On admitting the gas into the juice, the latter froths very much, which accounts for the necessity of having the receiving vessels of double the capacity of the deficators.

On the decomposition of the lime, the supply of gas is stopped; the liquor is then heated to the boiling point, and by means of a monte-jus elevated to a tank above the filters.

The deposit in the vessels, after the drawing of the liquor, is also subject to the action of the scum presses.

The filters are six in number, and of the bone-black variety, about thirty inches in diameter, by thirty feet high. Three of them are used for the first filtration. After leaving these filters, the liquor is carried to a series of three evaporaters. They are plate-iron vessels about eight feet diameter, by three feet deep, provided with a copper coil or worm at their bottoms. Steam is admitted into the coils, and the liquor concentrated to about 26° B; the scum arising during the boiling is also subjected to the action of the presses.

From the evaporaters, the juice is elevated by a second monte-jus to a tank above the second set of filters, and after this second filtration, passes to a vacuum pan, and is boiled down to the crystallizing point. Five centrifugal machines are employed for the purging operation. The sugar discharged from the vacuum pan is carried to a mixer, located on the floor above the five centrifugals; the mixer discharges into a traveling bucket arranged for supplying all the centrifugals.

The first product of this operation is a beautiful white sugar of heavy grain, ready for the drying tables and the market. The syrup evolved during this operation is re-boiled in the vacuum pan, and re-worked in the centrifugals, making a fair brown sugar.

The refinery is supplied with the ordinary washers and ovens for re-washing and revivifying the bone-black.

Steam is supplied by four forty-inch by thirty-feet double flue boilers, and two sixty-inch by thirty-feet boilers, the two latter each containing five flues. The fuel used is coal; it is not of very good quality, but is to be had in abundance, one shaft being worked in the village. The price is about ten cents per bushel.

This, like most new enterprises, has met with its discouragements.

The first attempt at sugar making on a large scale, was made during the autumn of 1866 and winter of 1867. Some of the machinery proved defective, and it was found impossible to obtain the requisite steam on account of deficiency of boiler power, and the want of a proper smoke-stack.

The beet crop was an abundant one, averaging some fifteen tons per acre, and would have required four and half months working of the refinery to manufacture into sugar, at an average of sixty tons per day; owing to the defects mentioned, not near this quantity was reached, and as a consequence, tons of beets had to be carted and thrown away to make room for the spring planting.

Although the enterprise proved a failure in a pecuniary point of view, yet the cause was plainly seen to have been a remediable mechanical one.

The product per acre proved the land to be well adapted to the culture of the beet, while the operation of the refinery, giving eight per cent. of sugar, compares favorably with the best results in Europe.

During the past summer, additional boiler power was placed and other defects remedied, and those interested had every reason to hope that this present season would give a rich reward for all the energy, perseverance, and patience they had displayed.

Unfortunately, this will not be the case, as this last has been the dryest season experienced in the West for a period of thirty years. No rain of any consequence has fallen since June, and the beet crop has proved a failure. It has been gathered, and gives an average of only three tons per acre, instead of fifteen, as on the previous year.

The season has been an exceptional one in Illinois, and the effects of the drought have been very serious. Most of the wells have failed, cattle have been and are dying from thirst, and the Illinois Central Railroad is carrying water from Chicago down their road for the use of their locomotives. Such a season may not again be experienced for many years.

Notwithstanding these discouragements, there can be no doubt of the final success of the enterprise.

Persons who have lived in the State some twenty years, and are familiar with its characteristics, assert, that good crops of beets can be had at least nine years out of ten.

The Messrs. Gennert have proved the feasibility of extracting the sugar in such quantities that there will be left a good margin of profit. They are the pioneers in this country of an enterprise which will eventually prove one of the most important elements of public prosperity.

The enterprise can be carried on profitably in nearly all of our Northern States,—those which can offer the advantages of cheap land, cheap labor, coal, lime, water, and a ready market are of course to be preferred.

As there can be no doubt in regard to our possession of the above facilities, then the only question to ask is, have we the engineering and mechanical skill to design and construct the proper machinery for the manipulation of beet root into sugar, and the enterprise to engage in and carry forward the project to a successful result?

In regard to the machinery, the question can be satisfactorily answered.

Nearly all the parts required are precisely similar to those manufactured in this city during the past twenty-four years for Louisiana, Cuba, and South America, for making sugar from cane juice, the only difference being in the pieces used for extracting the cane juice and beet juice, respectively. At Chatsworth, the evaporating is done in open kettles, which is an expensive mode so far as fuel is concerned, and is also destructive to the color of the liquor.

In Germany, in the best refineries, vacuum pans of treble effect are used for evaporating, three being generally employed.

They are placed near each other on one common platform, the first being worked by the exhaust steam of the different steam engines in the refinery, the second by the vapors of the boiling liquor of the first, and the third, or strike pan, by the vapors of the second.

The economy of this plan is self-evident, while the low temperatures required for boiling, as well as the absence of exposure of the liquor to the atmosphere, prevents the deleterious effects noticed by the use of open kettles. This system had its origin in this country, and has been most successfully practised for many years in Louisiana, Cuba, and South America, in the evaporation of cane juice.

The enterprising spirit required surely cannot be wanting. There has never been a lack of it in this country, and I feel sanguine that many years will not elapse, before all the sugar consumed in the country will be of domestic growth and manufacture.

The importance of getting all the saccharine matter from the raw beet, has resulted in many devices for its extraction. In Europe are employed for that purpose, hydraulic presses, centrifugals, cold maceration, and what is called the "*Diffusion Process.*"

The centrifugal process has been considered as best adapted for the purpose in this country, requiring but little labor in working, while the per centage of juice has been good as compared with the other modes.

A beet-root plantation and refinery is about being started at Aurora, near Chicago, Illinois, and is to be worked on the diffusion principal.

Those interested claim a gain of 1¼ to 1½ per cent. of sugar over every other mode, with less labor, and that the refuse or pulp is better as food for cattle.

European capital will be employed in this enterprise, and as Congress has exempted from duty all machinery needed in the manufacture of beet sugar, the major portion will be imported, while our own steam-engine and machine establishments, capable of doing the whole work, are suffering for want of orders.

In a future article will be given the details of the various processes employed for extracting the juice from the raw beet.

## FLAME REACTIONS.

By Professor Bunsen.

TRANSLATED BY PROF. CHARLES F. HIMES, PH.D., DICKINSON COLLEGE, CARLISLE, PA.

(Continued from vol. liv., page 331.)

2. *The fusibility* is determined according to the six grades of temperature before given. During the heating at increasing tempera-

tures, it must be noticed with the lens, whether the specimen decreases in size or puffs up, whether it gives off bubbles at or above the temperature of fusion, whether it is transparent after cooling, and what changes of color it suffers during or after its treatment in the flame.

3. *The volatility* is tested by volatilizing beads of the substance, of equal weight, upon platinum wire in the zone of fusion, and measuring thereby, in the simplest way, by means of a metronome, the time required for the volatilization. The instant at which it is completed can be recognized with a great degree of exactness, often even to the fraction of a second, by the sudden disappearance of the coloration of the flame. The platinum wire on which the bead is treated is protected during the weighing from atmospheric moisture in a test tube, Fig. 7. If the wire with the enclosing test tube is weighed once for all, and the weight of the bead to be volatilized added to it, the weighing off of the beads can be accomplished very rapidly by rendering them lighter or heavier, as may be necessary, by volatilizing a portion, or by fusing more of the substance on to it. The tests are best made with beads weighing about a centigramme. The portion of the zone of fusion in which the highest temperature, constant during the time required for comparative tests, prevails, is ascertained by moving a fine platinum wire placed upon the arm *a*, Fig. 5, with its end bent downward at a right-angle, slowly back and forth through the zone of fusion, and fixing it at the point where it glows most intensely. The beads to be volatilized must always be most carefully placed the same distance below the point of this wire. It must be noticed in this connection, whether the size of the flame does not change materially during the experiments, by reason of irregularity of pressure upon the gas. As unit of volatility, it is most convenient to adopt the time required to volatilize one centigramme of chloride of sodium. If this time be represented by $t_0$, and the time required for an equal weight of another substance by $t_1$, the volatility of the latter, compared with that of chloride of sodium, will be $v = \frac{t_0}{t_1}$.

Fig. 7.

To the annexed examples, from experiments by Dr. Hurtzig, I have added those of chlorides of rubidium and caesium.

I cannot omit to state that the relation between these numbers does not change inconsiderably when the temperature of volatilization and weight of the substance volatilized are different. It is so much the more striking, that an approximate relation should manifest itself between the volatility and atomic weight of the more easily volatilized, analogously constituted substances of the table,

| | Time of Volatilization. | Volatility. |
|---|---|---|
| Chloride of sodium | 84·25 | 1·000 |
| Sulphate of soda | 1267·0 | 0·066 |
| Carbonate of lithia | 736·5 | 0·114 |
| Sulphate of potassa | 665·2 | 0·127 |
| Carbonate of soda | 632·0 | 0·133 |
| Carbonate of potassa | 272·0 | 0·310 |
| Chloride of lithium | 114·0 | 0·739 |
| Chloride of potassium | 65·4 | 1·288 |
| Bromide of sodium | 48·8 | 1·727 |
| Bromide of potassium | 41·0 | 2·055 |
| Chloride of rubidium | 38·6 | 2·183 |
| Iodide of sodium | 35·7 | 2·360 |
| Chloride of caesium | 31·3 | 2·717 |
| Iodide of potassium | 29·8 | 2·828 |

which can scarcely be ascribed to accident. Thus the following numbers show that with those haloid compounds, which volatilize without a residue, the volatility increases directly as the atomic weight. Representing the atomic weights by A, and the volatility by V, $\frac{V}{A}$ will be found to be practically nearly constant.

| | A | V | $\frac{V}{A}$ |
|---|---|---|---|
| Chloride of lithium | 42·49 | 0·739 | ·0174 |
| Chloride of sodium | 58·43 | 1·000 | ·0171 |
| Chloride of potassium | 74·57 | 1·288 | ·0173 |
| Bromide of sodium | 102·97 | 1·727 | ·0168 |
| Bromide of potassium | 119·11 | 2·055 | ·0173 |
| Chloride of rubidium | 120·82 | 2·183 | ·0181 |
| Iodide of sodium | 150·07 | 2·360 | ·0157 |
| Chloride of caesium | 168·46 | 2·717 | ·0161 |
| Iodide of potassium | 166·21 | 2·828 | ·0170 |

Drops of water, alcohol, ether, and other easily volatilized substances brought into the flame upon platinum wire, do not boil, even in the hottest portion of the zone of fusion, and manifest, therefore, under these circumstances, the phenomenon of Leidenfrost's experiment.

4. *Coloration of the flame.* Many substances volatilized in the flame can be recognized by the peculiar kind of light which they emit as incandescent gases. These colorations appear in the upper oxydizing flame, if the substances producing them be placed in the upper reducing flame. Mixtures of substances producing different colorations of the flame are tested in the coldest portion of the base of the flame, at which place it is often possible to obtain, for an instant, the coloration produced by the more volatile, unmixed with that of the more difficultly volatilizable.

### B. *Oxidation and Reduction of Substances.*

The following methods are employed to detect substances by the appearances which they present upon oxidation or reduction, and to accomplish their separation in a form adapted to further testing.

1. *Reduction in small glass tubes.* This is employed more especially for the detection of mercury, or for the separation of sulphur, selenium, phosphorus, &c., in combination with sodium or magnesium. A supply of tubes of very thin glass, 2–3 millimetres wide, and about 3 centimetres long, should be prepared. About forty can be made out of a common test tube of thin glass, of the size of the thumb, by heating it uniformly in the lamp-flame until the glass becomes soft, then drawing it out slowly into long tubes of the required diameter, and breaking them by scratching them with a writing diamond, into tubes 6–8 centimetres long, and after drawing these out in the middle, fusing the part drawn out round. The test specimen, after being crushed to a fine powder on the lamp-plate, Fig. 3, with the steel blade *a*, Fig. 4, is treated in the tube either with charcoal and carbonate of soda, or with sodium, or magnesium alone. In the latter case, a piece of moderately thick magnesium wire, several millimetres long, is used, which is stuck into the substance placed in the glass tube. Sodium must be carefully freed from naphtha by means of blotting paper, and rolled between the fingers into a small cylinder, which is to be surrounded with the substance in the glass tube. The soot from oil of turpentine deposited on a porcelain capsule filled with cold water serves best as charcoal. After the tube containing the previously perfectly dried test specimen has been heated to the point of fusion of the glass, when the contents will usually be seen to glow, it is crushed when cold under a piece of paper with the steel blade upon the lamp-plate, in order to test the products of reduction further.

2. *Reduction on a small charcoal rod.* This affords the metals, fused to globules, or as spongy masses, and can often be carried out with certainty even with a particle of the substance weighing less than a milligramme.

A crystal of carbonate of soda, which has not effloresced, is brought near the side of the flame, and a common match, coated three-quarters of its length with the pasty drops, formed. If it is then slowly revolved in the flame, a crust of solid carbonate of soda will form around the charred wood, which, upon heating in the zone of fusion, melts, and is absorbed by the charcoal. In this way a small rod of charcoal is obtained, which is protected from ready combustion by its soda glaze. A portion of the substance to be tested, about the size of a millet seed, mixed by means of the knife, Fig. 4, upon the hand with a drop of the melted soda crystal to a pasty mass, is placed upon the end of the charcoal rod. After it has been fused in the lower oxidizing flame, it is passed through a part of the dark nucleus into the opposite hottest portion of the lower reducing flame. The period at which the reduction takes place can be recognized by the active effervescence of the soda, which after a few moments is checked by allowing the test specimen on the charcoal rod to cool in the dark nucleus. In order to isolate the separated metal, the end of the charcoal containing the test specimen is pinched off with the fingers, and rubbed with a few drops of water in a small, smooth agate mortar, when the metallic spangles will in most cases be clearly seen, without further washing by decantation. These metallic spangles can easily be freed from carbon and carbonate of soda, for further testing, by repeated careful decantation, and then rinsing on a flat piece of glass, best broken from an old chemical flask *of thin glass*,* and, after pouring off and soaking up the water by means of blotting paper, they can be obtained dry by warming moderately. Several tenths of a milligramme of the metal, isolated in this way, suffice, in most cases, for the preparation of a solution that will answer for all characteristic precipitations, if the reagents are drawn up into capillary glass tubes, and added by the milligramme, and the reactions that occur observed with aid of a lens. Iron, cobalt and nickel, which do not fuse to globules in the carbon rod, are drawn out of the mass, rubbed with water in an agate mortar, by means of the magnetic knife-blade, *b*, Fig. 4, rinsed with water on the knife-blade, and dried upon it high above the flame. If the blade is now drawn between the upper joint of the thumb and the lower one of the front finger, tightly pressed together, and the magnetic blade then brought near to the metals which have been wiped off, they will be attracted from the hand to it, and form a tuft that can readily be investigated by means of a lens, and by touching with a melted borax bead can be transferred to it in such quantity as may be desired. The residue sticking to the knife is wiped off on a piece of blotting-paper, in order to dissolve it with a drop of acid, by warming the paper over the flame, to test it further with reagents.

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* Watch-glasses are too liable to crack to be used for such operations.

3. *Deposits upon porcelain.* The volatile elements reducible by hydrogen and carbon can be separated as such, or as oxides, out of their compounds, and be obtained in the form of deposits upon porcelain. Such deposits are converted with extreme ease into iodides, sulphides, and other compounds, which afford very characteristic and valuable indications for the recognition of substances. The deposits consist of a thicker layer in the middle, which passes very gradually on all sides into a very delicate film. In order to distinguish these, the term *incrustation* is applied to the heavier part and *coating* to the lighter. Both exhibit, by reason of the very gradual transition, all gradations of color peculiar to the substances in different degrees of fine division. From ·1 to 1· milligramme of the substance suffices in many cases for these reactions. Many of them surpass in definiteness and accuracy Marsh's test for arsenic, and approximate in sensitiveness the spectral analysis.

(To be continued.)

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# METHOD OF QUALITATIVE ANALYSIS OF ANIMAL AND VEGETABLE COLORING MATTERS BY THE SPECTRUM MICROSCOPE.

By H. C. Sorby, F. R. S., &c.

(Continued from vol. liv., page 417.)

## 7. *Preparation of Colors.*

If the petals, leaves, &c., of plants be crushed in water, it very commonly happens that the color is rapidly decomposed and no clear solution can be obtained; but if crushed in a moderate quantity of spirits of wine, and the solution squeezed out, filtered and evaporated to dryness at a gentle heat, the coloring matter does not decompose, even when re-dissolved in water and filtered to remove anything not soluble in that liquid. This clear solution should then be evaporated to dryness at a gentle heat in a small saucer, and kept *dry;* for then the colors often undergo no important change in the course of many months, whereas, when kept dissolved in water or alcohol, they may quickly decompose. I have thus prepared the coloring matter of above a hundred different vegetable substances, some of which have become entirely changed, but a large number are apparently still unaltered. I have also kept a number of colors, sealed up in glass tubes, ready for direct examination, dissolved in alcohol, in strong syrup or in alum. Many have decomposed, but many have kept perfectly well, or have merely faded, and still give excellent spectra after above a year. I have also prepared and kept in the same manner some animal coloring matters, but comparatively few.

### 8. *Method of Examination.*

The colored substances are examined, when dissolved in water, alcohol, or other solvent, in the small glass cells already described, and the various reagents are added and mixed by means of a moderately stout platinum wire, flattened at one end and turned up square like a little hoe. I have made many experiments in order to ascertain what reagents are most serviceable in developing characteristic spectra, and have at length concluded, that, for general purposes, the following are the most convenient. Those which are solid are best kept in small bottles as coarse powder, and added to the small cells in a solid state, so that the quantity used may be more readily known.

### 9. *Reagents.*

Hydrochloric acid.
Citric acid.
Benzoic acid.
Boracic acid.
Bicarbonate of ammonia.
Carbonate of soda.
Diluted solution of ammonia.
Caustic potash.
Sulphite of soda.
Sulphate of protoxide of iron.
Alum.
Iodine dissolved in alcohol.
Bromine dissolved in water.
Solution of hypochlorite of soda.
Permanganate of potash.

This list might, of course, be very much extended, if we were to include such reagents as may be used in separating or decomposing colors by the ordinary chemical methods. In describing the effect of those named in this list, I feel that I could not avoid mentioning some well-known facts without breaking the thread of my argument; and therefore I trust it may not be thought out of place if I give a general account of the whole from the particular point of view required by the subject more especially before us.

The action of many reagents is so intimately related to different parts of the spectrum, as to show that there must be some connection between so-called chemical reactions and optical phenomena. Not that their effect is absolutely the same in the case of all colored substances, but generally only the *extent* differs, whilst the *character* of the change is uniform, unless, indeed, decomposition take place, and even then it has a tendency to conform to a general law.

### 10. *Solvents.*

Water and alcohol are the most useful solvents, and the spectra of the two solutions of the same substance often differ most strikingly; in fact, they often behave in other respects as if they were solutions of different substances. Sometimes the spectra are absolutely identical, but often well-marked narrow absorption bands are seen in the alcoholic solution, where they are almost or quite invisible in the aqueous. Very commonly the bands are seen in both, but not exactly in the same place, alcohol sometimes raising them to a higher part of the spectrum, and sometimes depressing them. Occasionally the spectrum of the dry material is like that of the alcoholic solution, and unlike that of the aqueous, as if the difference were due to the presence of water, but in other cases it is unlike both. At all events, the facts clearly show that a solvent has a most important action on the ultimate particles of the substance in solution, since it may produce a greater change in optical phenomena than even chemical combination. Undistilled hard water may act like a weak alkali.

### 11. *Acids and Alkalies.*

As far as optical phenomena are concerned, there is no absolute division between acids and alkalies; for we have every connecting link from the strongest acids to the strongest alkalies. In order to understand their action it is most essential to distinguish between what may be called "general absorption" and "local absorption bands." There may, perhaps, be no absolute line of division, but when seen to advantage they are affected in such a different manner that it is desirable to treat of each separately.

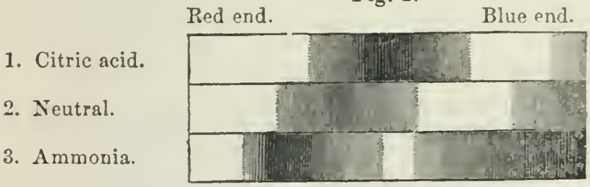
### 12. *General Absorption.*

As a good example of simple general absorption, we may take the crimson coloring matter of the common Wall flower (*Cheiranthus Cheiri*), which is soluble in water, and, along with a yellow only soluble in alcohol, gives rise to the varied colors of the flowers.

When neutral, it is crimson .... 2¾....7 10. .11- —
With ammonia, fine green .... 1¼—4½-..6 7 . . 8- - 9—
With citric acid deep pink .... 3½.-4½—6- . . 8½ 11...

The facts will be better understood by means of the following drawing:—

Fig. 2.



Whence it will be seen that citric acid raises and greatly increases the central absorption, and ammonia lowers and also increases it. At the same time, the absorption at the extreme blue end of the spectrum is raised by the acid almost to beyond the range of vision, but lowered to the centre of the spectrum by ammonia. Acids and alkalies of intermediate character, as for example, boracic acid and bicarbonate of ammonia, produce intermediate effects. These well-known phenomena may be looked upon as typical of acids and alkalies, but the extent of their action varies for each particular coloring matter, so that, in some cases, it is slight, and sometimes neither acids nor alkalies produce any effect. Their relative action on the central and upper absorption also varies very greatly in different colors. If there is no general absorption in the centre of the spectrum, when the color is neutral, but only an absorption at the blue end, acids and alkalies act on it in precisely the same manner as on the absorption at the blue end in the case just described, raising or lowering it to an extent varying greatly according to the substance; and the same may be said of any general absorption at the red end. The reverse certainly occurs when an acid is added to chromate of potash, or excess of ammonia to a salt of copper, and, according to Stokes (*Phil. Trans.*, 1862, p. 609), alkaloid bases usually show this reverse action. It may depend on the different properties of two distinct *compounds*, which does not appear to be the cause of the phenomena now under consideration. In the case of all the vegetable coloring matters which I have examined, the tendency of acids is to raise, and of alkalies to depress, the general absorption in each part of the spectrum; the extent of the action depending on the strength and quantity of the reagents, and on the nature of each coloring matter, and thus we have a general rule, and not several, as commonly adopted by chemists, each of very limited application; for instance, that vegetable blues are turned red by acids, and green by alkalies; and that vegetable yellows are reddened by alkalies. I may here remark, that some colors would appear to be exceptions, if we did not remember that waves of light, or waves analogous to them, exist beyond the visible spectrum. Thus, for example, when alkalies are added to the yellow solution of Brazil wood (*Cæsalpinia crista*), it is changed to pink, the absorption being so much lowered that the blues are transmitted; this clear space corresponding to what was probably a clear space beyond the blues visible under ordinary circumstances, but which would perhaps be seen, if examined in the manner described by Stokes in his paper on the long spectrum of electric light.*

### 13. *Fading of Solutions.*

One striking peculiarity in the action of acids on the solutions of many vegetable colors is, that when they are in a particular state of acidity, they fade to nearly or quite colorless, without their being any decomposition. This is especially the case with pink colors dissolved in alcohol. It occurs slightly with blue colors, and little, if at all, with yellows. The aqueous solutions change much more slowly, but more and more rapidly the more they are diluted; and frequently attain a permanent depth of color, which is dark or pale according as the solution is strong or dilute. Of course, I here allude to the effect of the *same total amount of color*, and not to the different effect of the same *quantity* of a strong or dilute *solution.* The alcoholic solutions obtained direct from the flowers often fade so rapidly, and become so nearly colorless, that any one might easily fancy that all the color was lost by decomposition, and an evaporating dish containing it might appear merely filled with a brownish alcohol, and yet on evaporation the whole dish might be covered with a fine deep color. The same change may occur over and over again, the deep coloration first obtained soon fading, and the color being restored by subsequent evaporation.

When such a color is dissolved in a little water and added to alcohol in an experiment tube, the color may at first be very deep, but may fade so rapidly that there is scarcely time to observe the spectrum before it passes into that molecular state which does not absorb any of the rays of light. The coloring matter of the red Salvia (*S. splendens*) is an excellent example. Neutral solutions do not undergo this rapid change; a different condition of acidity is requisite for different coloring matters; and some do not change at all. A large excess of citric acid very often restores the intensity of the color; and usually the absorption bands are seen to the greatest advantage when the solution is in that state which rapidly fades; and by adding too much color and watching whilst it fades, they may be seen and measured when at their best. This fading of a dark-colored solution must not be confounded with the change which takes place on diluting some salts as described by Dr. Gladstone in his paper on that subject.†

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* Phil. Trans., 1862, p. 599.

† Quart. Jour. Chem. Soc., vol. xi., p. 36.

### 14. *Absorption Bands.*

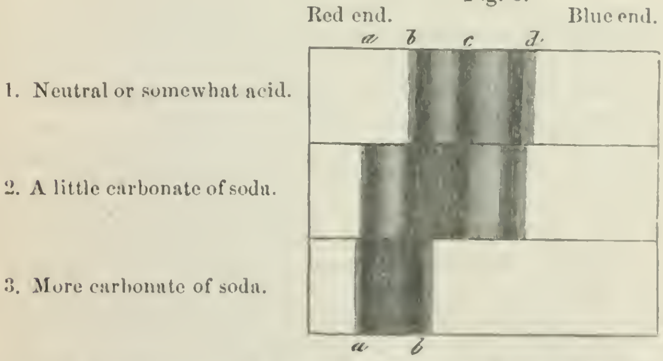
Though acids and alkalies thus, to a greater or less extent, alter the position of the general absorption, they act very differently on the special local absorption to which it is very convenient to restrict the term "absorption bands." Since I shall often have to speak of their being at equal intervals, it would be well to say that I have found it convenient to construct a wedge-shaped piece of quartz, cut parallel to the axis of the crystal, and to use it along with two Nicol's prisms in such a manner that the spectrum may be divided into any requisite number of equal portions, by interference bands situated in any requisite position. This, of course, avoids the errors which so often happen when we compare together measurements that cannot be made with very great accuracy.

As an excellent illustration I select the coloring matter of Alkanet root (*Anchusa tinctoria*). It is insoluble in water, but is easily dissolved by alcohol, even when much diluted with water, and gives a clear pink solution. The spectrum is nearly the same when the color is dissolved in absolute alcohol, as when much water is present, only each of the absorption bands is situated rather higher. Thus taking the centres of the band, we have—

| | *b.* | *c.* | *d.* |
|---|---|---|---|
| Absolute alcohol | $4\frac{3}{8}$ | $5\frac{7}{8}$ | $7\frac{3}{8}$ |
| Very dilute alcohol | $4\frac{1}{4}$ | $5\frac{3}{4}$ | $7\frac{1}{4}$ |

The general spectrum of the solution in dilute alcohol will be best understood from the following figure, No. 1:—

Fig. 3.


Red end.
Blue end.
a
b
c
d
1. Neutral or somewhat acid.
2. A little carbonate of soda.
3. More carbonate of soda.
a
b

Acids produce no important change, and the effect of alkalies is best seen by gradually adding carbonate of soda. This alters the color to a more blue-purple, and the spectrum is changed in the manner shown in Fig. 3. The three bands seen in the neutral solution may be referred to as *b*, *c* and *d*, and their centres occur at equal intervals of about $1\frac{1}{2}$. When enough carbonate of soda has been added to make it slightly purple, a fourth band, *a*, makes its appearance, separated from *b* by the same equal interval of $1\frac{1}{2}$, whilst the other bands remain in the same position as at first, only modified in intensity. The band *a* becomes darker and darker as more carbonate is added, until, when the solution is a fine purple, it is as dark as the others (see No. 2); and on adding more carbonate it becomes still darker, and the bands *c* and *a* more faint, until the solution is a purple-blue; and the spectrum has only the two well-marked bands *a* and *b*, shown by No. 3.

The bright blue coloring matter of the flowers *Lobelia speciosa* gives, when *neutral*, almost exactly the same spectrum as that of Alkanet root when *alkaline*, No. 3, having two well-marked absorption bands, whose centres are at 2¾ and 4¼; and on adding carbonate of soda, the upper one is gradually removed, and the centre of the lower is depressed to near 2½. More or less similar results occur in the case of many other blue coloring matters; and on adding a slight excess of acid the general absorption is raised, and other bands may be developed higher up, at equal intervals; but when a large excess has been added, they are lost in a strong general absorption. Too strong an alkali may also destroy narrow bands in a similar manner, as is well seen in the case of Brazil wood. The neutral aqueous solution shows an absorption band, made far more distinct by the addition of bicarbonate of ammonia, which makes it pink and very fluorescent. The spectrum is then

$$4\tfrac{3}{4}\overset{*}{—}5\tfrac{3}{4}\;.\;.\;.\;.\;.\;7;$$

but on adding excess of ammonia the solution ceases to be fluorescent, the narrow absorption band is lost, and the spectrum becomes

$$3\tfrac{1}{2}\;.\;\cdot\;4\tfrac{1}{4}—8\;\cdot\;.\;.\;9\tfrac{1}{2}.$$

Ammonia does not produce this effect when the color is dissolved in alcohol, the solution remaining fluorescent and still giving the narrow band; and, as a general rule, that solvent greatly impedes or entirely prevents such changes, and on this account almost invariably shows absorption bands to the greatest advantage.

We therefore see from the above examples that the absorption follows the general rule, and is raised by acids, and depressed by alkalies; but this only applies to the absorption when viewed as a *whole*, and not the separate bands; for those reagents change their *intensity*, but not their *position*. In some cases, indeed, their position is slightly altered, so that perhaps it would be more correct to say that acids and alkalies may raise and depress the general absorption to an extent equal to a considerable fraction of its own great breadth; whereas they either do not change the position of narrow absorption bands, or merely raise and depress them by a fraction of their own narrow width. It is their very definite position that makes them so useful in this method of analysis.

Unfortunately, I have not hitherto been able to find a sufficient number of coloring matters giving rise to three or more well-marked absorption bands, to warrant a general conclusion; and therefore it is perhaps premature to conclude that their centres always occur at *equal intervals*. At the same time it is certainly a very common fact. When the maximum point of transparency occurs between the different bands, there may be, as it were, a double interval; but then, sometimes, even this missing band may be seen under favorable conditions. A difference in the general absorption may also somewhat alter the apparent position of a band, if it is strongly shaded on one side, and not on the other; and the presence of impurities may also modify the results, so that absolute accuracy cannot be expected in all cases; and occasionally very narrow bands occur which appear to belong to a second system. It must be borne in mind that the bands are equidistant, only when measured by means of the interference spectrum. Thus, in the case of Alkanet root, when measured with a micrometer, instead of the intervals *a* to *b* and *c* to *d* being equal, they are related to one another about as 1½ and 2, and thus the general law is entirely obscured. If subsequent research should prove that the bands are normally at equal intervals, it will be a fact of great value in deciding whether certain spectra are or are not due to a *mixture of colors;* since, if a band occurred at a perfectly unequal interval, it would show that there must be at least two substances. Even in the present state of our knowledge, any inequality should make us carefully search for some satisfactory reason for such a divergence from a common rule. My meaning will be better understood from the following examples.

If a little of the color of Brazil wood be added to the solution of Alkanet root, the bands are not altered, and are seen at 4¼, 5¾ and 7¼; but a little bicarbonate of ammonia developes a well-marked band, whose centre is at 5¼, and therefore at an interval of 1, instead of 1½. The same is also well seen in the case of a mixed solution of Brazil wood and blue *Lobelia.* I therefore argue that if an unknown substance gave rise to similar spectra, with bands at unequal intervals, we ought strongly to suspect that it was either naturally composite, or that some new compound had been formed by decomposition. As a very good illustration, I may refer to the product of the action of acids on chlorophyll. The band in the red is not at an equal interval; but, on careful examination, it is seen to be made up of two bands, the upper of which is at an equal interval. I was not aware that these were due to two different substances, but was led to think it very probable; and Professor Stokes informs me that he has proved it to be the case. As an illustration of another kind of exception, I refer to the coloring matter of the pink Stock (*Matthiola annua*). The aqueous solution shows two bands, whose centres are at about 3⅝ and 5¼; and on adding ammonia the upper is removed, and the lower depressed to 3¼. In spirit of wine they are at 4 and 5½, and ammonia develops a third at 3, which are *not* equal intervals. However, if absolute alcohol be used, the bands are at 2¾, 4⅛, and 5½, which are *equal* intervals; and thus we see that the abnormal inequality is due to the presence of water, which causes the spectrum to be as if due to a mixture of two colors, when in reality it is the same color dissolved in two solvents.

(To be continued.)

# EDUCATIONAL

## THE MAGIC LANTERN

AS A

## MEANS OF DEMONSTRATION.

(Continued from vol. liv., page 342.)

HAVING now discussed the various preliminary arrangements as to the manufacture and storage of gases, arrangement of jets, of lanterns, and of lenses, we will proceed to describe the various experiments which may be performed with the instrument under consideration.

In the first place, if the lantern is to be used not simply for the exhibition of pictures, but, as we assume in this discussion, for the general demonstration of optical, chemical, electrical and other phenomena, the objective lens or lenses should be supported, not by a continuous tube from the condensers, but by a separate stand, as shown roughly in Fig. 10, vol. liv., page 132, leaving an open space between condensers and objective. A large disk or diaphragm attached to the stand or cell holding the objective, will prevent any scattered rays from reaching the screen under any circumstances. Should a prism, or other body reflecting light strongly, be interposed, a little tube of stiff paper, blackened within, may be readily arranged and attached to some portion of the apparatus. This, however, is seldom needed.

A little table or bench placed in front of the condensers, and rising as high as their lower edge, with several slips of wood or blocks of various thickness, will furnish convenient support to the objects employed. Among these, we shall first describe

### *Tanks, with their various Forms and Applications.*

The tank for a magic lantern, which we have found in all respects most convenient and efficient, is constructed as follows:—

Four simple screw-clamps, such as are shown in the following figures, each capable of embracing an object three-quarter inch thick, are provided two plates of glass, either plate or flat sheet, three and a half by four and a half inches, and a square strip of sheet rubber eleven inches long, and a half inch in each of its other dimensions. This is easily obtained from the thick sheets, manufactured and sold for pump and other packings. Notches are cut in the rubber at the proper points, it is bent to form three sides of a rectangle, placed between the glasses, and the whole firmly secured by means of the clamps. With a simple tank of this description, a great number of very beautiful and instructive experiments may be performed.

Thus, to illustrate the effect of refraction upon light, the tank may be nearly filled with water and some highly refracting solution, or liquid, such as muriate of tin of the shops (solution of protochloride of tin with excess of hydrochloric acid), alcohol, or even salt water poured in from a pipette. For this and many other purposes, it will be found extremely convenient to attach to the upper end of the pipette, one of the elipsoidal rubber balls, now easily obtained, when, by manipulation of this, a liquid may be drawn into or expelled from the pipette, with great convenience and promptitude.

In the experiment above described, the appearance upon the screen while the refracting liquid is being introduced, is that of a submarine volcano, belching forth vast clouds of black smoke and lava, which are, however, rapidly dissolved in the surrounding ocean. When the density of the liquid has been changed in a marked degree, a similar effect may be produced by a jet of fresh water.

In this and other cases, it is very desirable to use water deprived of air by previous boiling, as the formation of bubbles on the sides of the tank is thus prevented.

Again, a solution of cochineal in alcohol, introduced in a tank of water as above, exhibits on the screen a magnificent crimson fountain, shooting up twenty or thirty feet, curling over, and falling down in the most graceful curves and convolutions, while the dark outlines and shades which it develops, exhibit the same effect of refraction as before. A further illustration explanatory of the same property, may then be furnished, by introducing a small empty test-tube into the tank, and then allowing it slowly to fill with water from the same. The empty test-tube will be black on the screen, except a bright streak along the middle, but as fast as it fills, will become clear and transparent. A similar action may be shown, as we have before mentioned, by placing a small wine-glass (or, with a large lantern, a goblet) as an object, and filling it with water. In this case the empty glass is clear, but becomes black when filled.

To illustrate chemical reactions, we introduce, for example, solution of litmus, covering the screen with a delicate blue sky. A few drops of weak acid being then introduced, and allowed to mingle slowly, gives us beautiful combinations and changing forms, of red and yellow clouds, as seen in a sunset sky.

Again we place in the tank of water a little sulphate of copper solution, and force into this weak ammonia from the pipette. We have then upon the screen an impressive display of rolling and surging clouds, first accumulating to blackness, but then dissolving, as they sweep about, into a serene blue. Dilute sulphuric acid affects like changes in an inverse order, and a few drops of ferrocyanide of potassium then develops a red-brown precipitate in huge curdled masses, which look as though they might weigh tons.

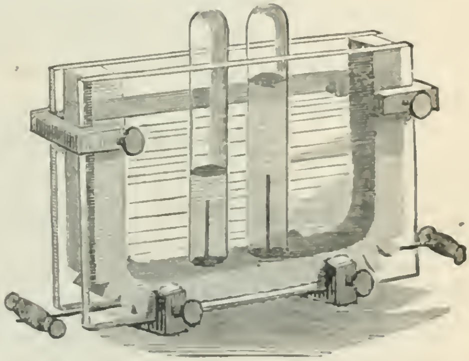
In fact, these experiments, which, as all can see, may be modified without limit, add to their intrinsic beauty a new element, grandeur, from the seeming hugeness and overwhelming quantity of the materials employed, as shown upon the screen. Solutions by tons, precipitates by the cart-load, even though seen but in images, convey a strong and peculiar impression to the mind.

When a number of such experiments are to be exhibited in succession, a great improvement may be effected as regards convenience and rapidity of manipulation, by arranging the tank as follows:—With a wet cork-borer, three holes are made in the rubber strip, one at either side near the upper edge of the tank, and one beneath at the lowest part; short glass tubes are inserted in each of these, and by means of rubber hose are connected as follows:—One of the upper openings, with a bottle or jar of water placed on a shelf above, and provided with a stop-cock or nipper-clip; this serves to introduce fresh water. The other upper and the lower opening, by means of a T connection, communicate with an escape-pipe leading to a bucket or like receptacle. Close to the lower opening is placed a nipper-clip; the upper one, or overflow, is never closed. When one experiment has been performed, we press the clip of the outlet, when the contents of the tank escape, producing on the screen the appearance of a curtain rolling up. The clip or stop-cock from the supplying vessel being then opened, the tank is filled, and a fresh curtain of clear water rolls down upon the screen.

To illustrate the change in color produced by chemical reaction, we may introduce one of two reagents, *e. g.* pernitrate of iron, in the tank, and the other, *e. g.* sulphocyanide of potassium, in a test-tube. Two liquids are thus seen in apparent contact, but without reaction until the tube is inverted, when the liquids mingle and produce the well-known crimson coloration. The solution of zinc in dilute sulphuric acid, develops another of the pleasing effects which may be shown with this simple apparatus.

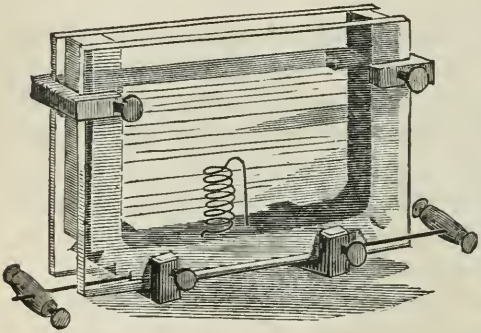
Passing now to the department of electricity, we may again display the galvanic decomposition of water, with a tank arranged as in Fig. 17. Though for the best effect, we here require to correct the inversion of the image, and this may be best accomplished by one of Mr. Zentmayer's prisms, fully described in this Journal (vol. liii., page 406). In this tank, two stout copper wires, with strips of platinum soldered to them, are thrust through the bottom of the tank, and connected with the battery by binding screws outside. Small test-tubes are then filled with water, and may be inverted in the air without the water running out, and may therefore be easily placed over the platinum strips in the tank. With a moderate battery (five or six Bunsen elements), we see upon the screen the liberated gases, in bubbles of perhaps ten gallons each, collecting in reservoirs whose capacity could be best expressed in hogsheads. Other electric changes of decomposition may be in like manner exhibited in U tubes emersed in tanks, or in tanks provided with porous or perforated partitions. So again a small electro-magnet, lifting filings, tacks, or beads, and dropping them again, may be exhibited most clearly.

Fig. 17.



Another fact in physics which it is impossible to show to a large audience, is the convection of heat by liquids, and this the lantern tank demonstrates most clearly. We arrange a tank as in Fig. 18, with a coil of platinum wire, which may be heated in a moment by connection with the battery. The tank is filled with water, a little aqueous solution of cochineal being introduced at the bottom; it is then placed in the lantern, and its image, erected by the prism, is projected on the screen. We connect with the battery, and at once a crimson column of the heated liquid rises from the wire helix (which looks like a steam coil), and rolls over in graceful curls at either side.

Fig. 18.



(To be continued.)

## Franklin Institute.

### Proceedings of the Stated Monthly Meeting, November 20th, 1867.

The meeting was called to order with the President, Mr. J. V. Merrick, in the chair.

The minutes of the last meeting were read and approved.

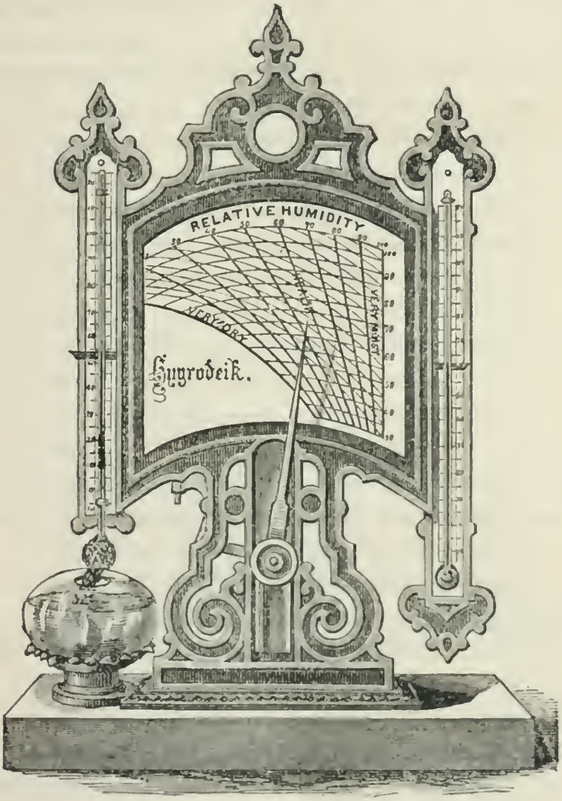
The Actuary submitted the minutes of the Board of Managers, and reported that at their stated meeting held November 13th, inst., a letter was received from the Secretary of the Royal Institution of London, at the request, on the part of the family of Professor Faraday, to communicate to the Secretary of the Franklin Institute the death of the Professor on the 25th of August, in the 77th year of his age.

On motion, a committee was appointed to prepare suitable resolutions in relation to Professor Faraday.

Donations were received from the Royal Astronomical Society, Chemical Society, and the Statistical Society of London, and the Association for the Prevention of Steam-Boiler Explosions, Manchester, England; the Literary and Historical Society, Quebec, Canada; the Hon. William D. Kelley, member of Congress, Washington, D. C.; Professor Albert R. Leeds and James D. McIntyre, Philadelphia.

The various Standing Committees reported their minutes, and the Committee on Experiments in Steam Expansion reported progress.

The report of the Resident Secretary, on Novelties in Science and the Mechanic Arts, was then read, after which Mr. Robert Briggs described, with diagrams projected on the screen, as is usual at the meetings of the Institute, Edson's Hygrodeik, or instrument for showing at a glance the amount of moisture contained in the air.



One of these instruments shown in the accompanying cut, was also exhibited. They are manufactured by N. M. Lowe, No. 103 Court street, Boston, whose connection with the apparatus is thus expressed by the inventor: "Mr. N. M. Lowe, the manufacturer of the instrument, and to whom the credit of the beautiful mechanical details and finish is due, is now designing a barometer of such a nature that it may be combined with the hygrodeik."

The description of this apparatus given by Mr. Briggs is as follows:

The instrument is the usual arrangement of a wet and dry bulb thermometer upon a stand, as shown in the accompanying illustration. Between the two thermometers is placed a scale and pointer, the extremity of which, when it has been moved so as to bring the sliding marks on the two thermometers to correspond to the heights of mercury they indicate, will show at one view the per centage of moisture present as compared to total saturation, the grains of water to each cubic foot of air, and the tension of vapor in inches of mercury. Any person who has had occasion to calculate any of these physical data from the psychrometer (or wet bulb thermometer) by the aid of tables, will appreciate the relief which this instantaneous solution of the problem affords.

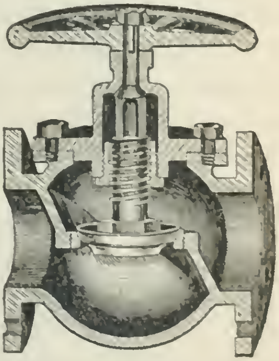
With the same precautions as to exposure of the two thermometers to protect them from external influences of radiation, imperfect contact with the air, and especially an observance of the precautions needed for the wet bulbs, that the water should be free from salts, the wick clean, and the bulb fanned to remove its own little atmosphere of vapor when taking an observation; it is perfectly possible to so form the scale that its indications shall be as accurate as calculation. The construction of the indicating part is very simple. At the back of the instrument is an upright bar in line with the thermometers, which carries a slide to which the pointer is attached. To this slide is fixed a rigid arm, which carries the mark on the dry thermometer side, so that by raising or depressing the slide by the knob in front, the mark is placed opposite the surface of the mercury column on that side. The pointer is attached to this knob as a centre of movement. Behind the slide, on the axis of the knob, is an arm about one-third as long as the pointer, which elevates and depresses the mark on the wet bulb side.

By examining the illustration, it will be noticed that when the mark on the dry side is at any degree, the end of the pointer will, if it is swung across the scale, follow the circular path or line of degrees corresponding, and, as has been described, swinging this pointer elevates or depresses the mark on the wet side, the end of the pointer showing by the divisions across the circular lines the per centages of humidity. The diagonal cross lines crossing both the temperature and the per centage lines, give similarly the grains of vapor per cubic foot of air, and the tension of vapor in inches of column of mercury.

In describing this instrument, Mr. Briggs took occasion to remark, that, aside from its value as a meteorological instrument of observation and its application to some hygrometric purposes connected with manufacturing operations, such as paper-making, fine muslin or lace-working, drying of delicate materials, &c., it was peculiarly valuable and satisfactory at this time, in forming a ready and perceptible way for overthrowing some current fallacies as to moisture for hygienic demands.

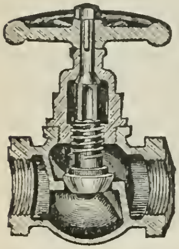
He said that the great cause of the unhealthfulness of our climate, as of all temperate climates, lies in the varying condition of atmosphere as to moisture. That with our colder northerly and northwesterly winds, the external air had an extreme low dew point, and while it was possible to warm the air when such winds prevail to the comfortable temperature of 70° to 80° (the English maximum comfortable temperature being 62°), it was neither practicable nor desirable to impart to it any addition of moisture. Any such addition as should give a summer dew point, would involve an expenditure of fuel two-thirds as great as that of heating the air, and an evaporation of quantities of water far beyond any pan contrivances ever devised, requiring regular steam-boilers to be attached to each house furnace. More than this, the effect on the lungs in changing from the summer air within doors, to the winter one without, would aggravate all the derangements from difference of temperatures solely, in the most serious manner. In fact, this instrument would lead physicians and observers to the knowledge of the fact that the presence of any considerable quantity of moisture beyond that existing out of doors, at the same time of moisture in a habitable room, was a sure indication of its want of ventilation and its insalubrious condition.

Shaffer's patent self-packing valve was then exhibited in model and by sectional diagram, and its construction and purpose described. The accompanying illustrations show the internal arrangement and the method by which it is proposed to dispense with a stuffiing-box or gland about the stem of the valve.



The general form is that of the ordinary globe-valve, of the most approved construction, made either entirely from brass or with iron bodies and centre-piece or cap, and brass valve, valve-stem, nut, and seat.

The valve-stem proper, to which the wheel or handle is attached, has a conical enlargement, which is brought, by a nut on the top of the wheel, to bear upon a seat formed within the valve on the centre-piece, making a steam-tight joint.



Below this enlargement the stem has the form of a key, two nearly semicircular grooves being cut in it lengthways. This key end is inserted, loosely, into a socket formed in the end of the screw, which opens or closes the valve. The screw runs in a nut, which is either made in or affixed to the centre-piece of the valve: to this screw is attached, by collar and nut, the disk of the valve, the disk being free to rotate upon the lower end of the screw.

It has been before proposed to make self-packing valves similar to this, except in one respect; all former plans putting the screw upon the valve-stem, and running into a nut within a key attachment to the disk, the key guiding itself in a socket made in or affixed to the centre-piece.

The effect of such an arrangement is, that the pressure of seating the valve is expended upon the seat about the stem, and the twisting movement quickly wears it so that it ceases to be steam-tight. Besides, in such case, when the valve is seated, the screw, unless it is perfectly in line with the stem, strains its seat by the sideways pressure, and leaks. The construction patented obviates both these defects, and has been found by the past year's use to move easily, and to keep in perfect condition under continued service. The key is made in the shape shown, in preference to square or any other form, to prevent its binding in the socket when turned, as the surface of contact at such time is normal to (square with) the motion imparted. It was stated that 5000 or 6000 of these valves are now in use.

After this Mr. Vanderburgh gave a description of the new process for the manufacture of artificial stone, by mingling sand and dry lime under influence of high pressure steam. (A full description of this process is promised for a future occasion.)

Prof. R. E. Rogers made some remarks on the importance of potash in all reactions developing artificial silicates.

Some questions were asked by other members, and replies given by Mr. Vanderburgh, after which the meeting, on motion, adjourned.

HENRY MORTON, *Secretary.*

A COMPARISON *of some of the Meteorological Phenomena of* NOVEMBER, 1867, *with those of* NOVEMBER, 1866, *and of the same month for* SEVENTEEN *years, at Philadelphia, Pa.* Barometer 60 feet above mean tide in the Delaware River. Latitude 39° 57½′ N.; Longitude 75° 11¼′ W. from Greenwich. By PROFESSOR J. A. KIRKPATRICK, of the Central High School.

| | November, 1867. | November, 1866. | November, for 17 years. |
|---|---|---|---|
| Thermometer—Highest—degree | 69·00° | 70·00 | 80·00 |
| " date | 9th. | 29th. | 1st, '60. |
| Warmest day—mean | 62·33 | 64·50 | 72·30 |
| " " date | 9th. | 29th. | 9th, '57. |
| Lowest—degree | 24·00 | 29·00 | 16·00 |
| " date | 19th. | 26th. | 25th, '60. |
| Coldest day—mean | 31·00 | 35·83 | 23·30 |
| " " date | 18th & 19th. | 24th. | 25th, '60. |
| Mean daily oscillation | 14·47 | 13·63 | 13·26 |
| " " range | 6·37 | 5·85 | 5·70 |
| Means at 7 A. M. | 42·93 | 42·95 | 41·40 |
| " 2 P. M. | 51·33 | 52·33 | 50·43 |
| " 9 P. M. | 46·68 | 46·93 | 44·69 |
| " for the month | 46·98 | 47·40 | 45·51 |
| Barometer—Highest—inches | 30·342 | 30·358 | 30·661 |
| " date | 5th. | 5th. | 12th, '51. |
| Greatest mean daily pressure | 30·325 | 30·327 | 30·520 |
| " " " date | 5th. | 5th. | 12th, '51. |
| Lowest—inches | 29·250 | 29·327 | 29·080 |
| " date | 29th. | 16th. | 4th, '64. |
| Least mean daily pressure | 29·593 | 29·382 | 29·150 |
| " " " date | 29th. | 16th. | 4th, '64. |
| Mean daily range | 0·182 | 0·157 | 0·182 |
| Means at 7 A. M | 30·006 | 29·913 | 29·915 |
| " 2 P. M | 29·972 | 29·858 | 29·870 |
| " 9 P. M | 29·994 | 29·891 | 29·902 |
| " for the month | 29·991 | 29·887 | 29·896 |
| Force of Vapor—Greatest—inches | 0·548 | 0·513 | 0·832 |
| " date | 10th. | 29th. | 8th, '57. |
| Least—inches | ·100 | ·060 | ·055 |
| " date | 18th. | 25th. | 25th, '57. |
| Means at 7 A. M | ·236 | ·218 | ·224 |
| " 2 P. M | ·256 | ·213 | ·229 |
| " 9 P. M | ·258 | ·242 | ·234 |
| " for the month | ·250 | ·224 | ·229 |
| Relative Humidity—Greatest—per cent | 94·0 | 89·0 | 100·0 |
| " date | 10th. | 11th & 26th. | Often. |
| Least—per cent | 41·0 | 25·0 | 25·0 |
| " date | 16th. | 25th. | 7,'63 & 25,'66 |
| Means at 7 A. M | 80·3 | 74·6 | 77·2 |
| " 2 P. M | 63·0 | 51·0 | 58·8 |
| " 9 P. M | 76·5 | 71·0 | 73 3 |
| " for the month | 73·3 | 65·5 | 69·8 |
| Clouds—Number of clear days* | 8· | 10· | 8·5 |
| " cloudy days | 22· | 20· | 21·5 |
| Means of sky covered at 7 A. M | 65·0 per ct | 56·7 per ct | 60·6 per ct |
| " " " 2 P. M | 66·0 | 56·7 | 60·6 |
| " " " 9 P. M | 50·0 | 49 0 | 51·8 |
| " " for the month | 60·3 | 54·1 | 57 7 |
| Rain—Amount—inches | 2·540 | 1·474 | 3·559 |
| No. of days on which rain fell | 10. | 7· | 10·1 |
| Prevailing Winds—Times in 1000 | s76°32′w·261 | s84°17′w·251 | s74°47′w·255 |

* Sky one-third or less covered at the hours of observation.

A Comparison *of some of the Meteorological Phenomena of the* Autumn *of* 1867, *with that of* 1866, *and of the same Season for* seventeen *years, at Philadelphia, Pa.* Barometer 60 feet above mean tide in the Delaware River. Latitude 39° 57½′ N.; Longitude 75° 11¼′ W. from Greenwich. By Prof. J. A. Kirkpatrick, of the Central High School.

| | Autumn, 1867. | Autumn, 1866. | Autumn, for 17 years. |
|---|---|---|---|
| Thermometer—Highest—degree | 86·00 | 91·00 | 95·00 |
| " date | Sept. 19. | Sept. 3. | Sept. 12, '51. |
| Warmest day—mean | 77·83 | 82·00 | 85·20 |
| " " date | Sept. 6. | Sept. 2. | Sept. 6, '54. |
| Lowest—degree | 24·00 | 29·00 | 16·00 |
| " date | Nov. 19. | Nov. 26. | Nov. 25, '60. |
| Coldest day—mean | 31·00 | 35·83 | 23·30 |
| " " date | Nov. 18 & 19. | Nov. 24. | Nov. 25, '60. |
| Mean daily oscillation | 14·79 | 13·83 | 14·80 |
| " " range | 5·67 | 5·47 | 5·29 |
| Means at 7 A. M. | 52·25 | 53·52 | 57·99 |
| " 2 P. M. | 62·83 | 63·44 | 62·63 |
| " 9 P. M. | 56·42 | 56·87 | 55·70 |
| " for the Summer | 57·17 | 57·94 | 56·77 |
| Barometer—Highest—inches | 30·466 | 30·358 | 30·661 |
| " date | Sept. 24. | Nov. 5. | Nov. 12, '51. |
| Greatest mean daily pressure | 30·456 | 30·327 | 30·520 |
| " " " date | Oct. 24. | Nov. 5. | Nov. 12, '51. |
| Lowest—inches | 29·250 | 29·327 | 29·012 |
| " date | Nov. 29. | Nov. 16. | Oct. 26, '57. |
| Least mean daily pressure | 29·593 | 29·382 | 29·059 |
| " " " date | Nov. 29. | Nov. 16 | Oct. 26, '57. |
| Mean daily range | 0·164 | 0·146. | 0·150 |
| Means at 7 A. M. | 30·048 | 29·895 | 29·929 |
| " 2 P. M. | 30·009 | 29·838 | 29·887 |
| " 9 P. M. | 30·024 | 20·877 | 29·914 |
| " for the Summer | 30·027 | 29·870 | 29·910 |
| Force of Vapor—Greatest—inches | 0·812 | 0·864 | 0·991 |
| " date | Sept. 17. | Sept. 2. | Sept. 6, '54. |
| Least—inches | 0·100 | ·060 | ·055 |
| " date | Nov. 18. | Nov. 25. | Nov. 25, '57. |
| Means at 7 A. M. | ·345 | ·358 | ·340 |
| " 2 P. M. | ·375 | ·366 | ·357 |
| " 9 P. M. | ·379 | ·391 | ·360 |
| " for the Summer, | ·366 | ·371 | ·352 |
| Relative Humidity—Greatest—per cent | 100·0 | 96·0 | 100·0 |
| " date | Oct. 29. | Oct. 13. | Often. |
| Least—per cent. | 28·0 | 25·0 | 23·0 |
| " date | Sept. 30. | Nov. 25. | Oct. 21, '59. |
| Means at 7 A. M. | 80·6 | 78·2 | 77·8 |
| " 2 P. M. | 59·9 | 55·5 | 57·2 |
| " 9 P. M. | 76·4 | 75·6 | 73·7 |
| " for the Summer | 72·3 | 69·7 | 69·6 |
| Clouds—Number of clear days* | 31· | 28· | 29·2 |
| " cloudy days | 60· | 63. | 61·8 |
| Means of sky covered at 7 A. M | 62·0 per ct | 64·2 per ct | 58·5 per ct |
| " " " 2 P. M | 53·2 | 54.5 | 56·0 |
| " " " 9 P. M | 44·0 | 47·9 | 43·0 |
| " " for the Summer | 53·1 | 55·5 | 52·5 |
| Rain—Amount—inches | 8·410 | 12·469 | 10·840 |
| No. of days on which rain fell | 24· | 26· | 27·1 |
| Prevailing Winds—Times in 1000. | s86°12′w·209 | n.72°1′w·161 | n78°22′w·221 |

* Sky one-third or less covered at the hours of observation.

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OF THE STATE OF PENNSYLVANIA,

FOR THE

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Vol. LV.] FEBRUARY, 1868. [No. 2.

# EDITORIAL.

## ITEMS AND NOVELTIES.

**Electric Car Starter,** invented and patented by John and William H. Clark.—The present plan of regulating the time at which the various city cars on any route leave the depot or station, is to employ a man whose duty it is to notify the various conductors. Besides the expense involved in this arrangement, there are various other objections which have shown themselves in practice. Thus, a little delay or irregularity inseparable from human agency; a little favoritism, or at least a suspicion of such, trifling in themselves, occasion disputes, and greater irregularities in the running, by which the service of the companies and of the public suffers detriment.

The apparatus named above, a working model of which was exhibited at the last meeting of the Institute, obviates the various difficulties mentioned.

It consists of an attachment to a clock, which may be placed in the superintendent's office, which will cause a bell to be rung at certain intervals, at any convenient point, near or distant. The length of interval between ringing may be changed at any time, in a moment, without in any way disturbing the action of the apparatus, or affecting the time of the regulating clock. It would be impossible, without several drawings, to give a correct idea of the mechanical details involved; but we may state that they are well arranged, efficient, and durable.

**Lead Manufacture in San Francisco.**—Extensive works are under way in the above place for the manufacture of lead on a large scale. The supply of ores is very abundant, and generally sufficient silver is found contained in it to pay for transportation and working.

**A Constant Battery.**—Boettzer has constructed a galvanic battery of such constancy that it retains its activity for several years, and is admirably adapted to the working of electric clocks, ringing electric bells, and the requirements of electro-metallurgy.

Each cell consists of a cylinder of thick plate zinc, enclosed in a glass jar. In the centre of the cylinder is placed a bar of compact coke, and the intervening space is packed with a powder composed of a mixture of equal volumes of pounded sulphate of magnesia and common salt, moistened with a saturated solution of these two substances. The salt mixture is moistened from time to time.—*Artizan.*

**The Mont Cenis Tunnel** advanced 109 metres, or 357 feet, during November.

**The American Tube Well,** of which we gave a brief account in our December number, increases in favor not only in England, where it has been lately introduced, but in France also. Its peculiar merits consist not only in its cheapness, but in its entire freedom from surface drainage, and when water is reached, if it should not prove sweet, the tube may be sunk beneath that bed until pure water is obtained.

**Gold Yield.**—The yield of gold in this country for the past year amounted to $74,000,000.

**Liebig's Extract of Meat.**—Soon after Baron Liebig's process for extracting and preserving the nutritive principles of meat had been perfected, an enterprising German established works for the treatment of meat on this principle in South America, a situation where cattle abound, and the meat is of little commercial value on account of the impossibility of shipping it to a market. By this process of concentration, a single pound of meat extract is said to represent a quarter of a hundred weight of the best beef, and, in such small bulk, may be transported very advantageously. The enterprise above mentioned proving very successful, the proprietor then went to Europe and organized a joint stock company, establishing its work in the Argentine Republic, having its head office in London and its chemical laboratory in Germany, under Baron Liebig's immediate supervision. Here samples of every week's production are carefully analyzed, thus insuring the confidence of the public. The company are now capable of turning out one million pounds of beef extract annually. The extract of meat has not yet become a staple article of commerce, but is confined chiefly to the use of invalids, owing to its high price. This is more or less the case with all new manufactures; but the great success which has attended this enterprise has induced rival establishments, and we may look for competition to reduce the price to more marketable rates.

**Sulphuric Acid.**—A new process for the manufacture of sulphuric acid has been patented in France, by means of which it is claimed that the immense leaden chambers are dispensed with, and the entire apparatus occupies forty times less space than that required by the old plan.

The sulphurous acid gas, formed by the burning of sulphur or pyrites in compressed air, is washed before being brought in contact with the nitric vapors.

The combination takes place in a small leaden chamber so arranged that the sulphuric acid is drawn off as soon as formed. By this apparatus, it is stated in the *Mechanics' Magazine*, the sulphuric acid is obtained free from many of the impurities ordinarily found in it.

**Solar Eclipse in 1868.**—There is in preparation a scientific expedition into India, to take observations of the eclipse of the sun during this year; it will have an extraordinary duration, presenting an exceptional interest. The English astronomers have chosen a station situated in the chain of the Himalaya mountains at an elevation of 7000 feet above the sea, in order to augment the chances of escaping the clouds. They bring with them the instruments necessary to study from all points of observation possible—the rose-tribe protuberances—the origin of which is still so obscure.—*Cosmos.*

**The Hicks Engine.**—Some time since we drew attention to the above invention, and stated that we hoped shortly to furnish our readers with a full account and description, accompanied by drawings. Various alterations and improvements have, however, delayed the preparation of these last, and we have not even now received the full material. From time to time, however, favorable accounts have reached us, and among these is the report which we give herewith, a report furnished, as will be seen, by a gentleman of high professional standing, and in a position securing ample means of investigation.

REPORT OF MR. MARK B. HORNE, Mechanical Expert and Chief Engineer of the Merrimack Mills, Lowell, Mass:—

MIDDLESEX MECHANICS' ASSOCIATION,
*Lowell, Mass., October* 11*th*, 1867.

This is to certify that I have examined and tested, as an expert, at the request of the Committee of Judges, in the Department of Machinery, at the Fair of the Middlesex Mechanics' Association, now open in the City of Lowell, a W. C. HICKS Patent Steam Engine, in use at the Works of the Salem Machine Co. at Salem, Mass., of six (6) inch cylinders and six (6) inch stroke, rated and sold as a fifteen (15) horse-power engine.

The following claims of superiority over other engines were made by the manufacturers, and submitted to me for examination, viz:—

1. That it is more correct in principle, while not conflicting with the well established theories of the best engineers.
2. That it can be more cheaply constructed.
3. That it will be more durable.
4. Greater economy in space and weight.
5. Greater economy in fuel.
6. Greater economy in lubrication and packing.
7. Greater economy in care and attention.
8. The friction being less, that it will transmit more effective power to the machinery to be driven. On these points, I give my opinion as follows:—

1. *Principle.*—It is more correct in principle, because it accomplishes the same results by a far greater simplicity of construction. Its mode of admitting, suppressing and exhausting steam, while the same in theory, is more direct, and therefore more effective and economical than in the best built modern engines.

2. *Cheaper Construction.*—This is apparent from the small num-

ber of parts—from its being almost entirely made without handwork, and from the economy of material, the engine weighing not over one-fourth as much as other approved engines.

3. *Durability.*—From the fact that the parts are so few, and at the same time have such large bearing surface, it is apparent to me that its durability must be proportionably increased—ample evidence from parties using these engines from twelve to eighteen months was furnished me to support this opinion.

4. *Space and Weight.*—I find, by actual observation, that it occupies only about one-fourth of the space of the Corliss Engine, and weighs less than one-half as much as the balance wheel of that engine of corresponding power.

5. *Fuel.*—From the simplicity of parts, the direct operation of the steam, the reduction of friction, the diminished length of the steam-ports and clearances, and the accuracy of the valve motions, I am convinced that the claim should be admitted; and the ample testimony of parties having these engines in use, which was submitted to me, fully confirms this judgment. I learned from the shop records, that the engine examined has for the past five months performed a greater amount of work than a slide-valve engine of one of the best Boston makers, previously occupying the same place, with an average saving of 168 pounds of coal per day, in a daily consumption of 680 pounds, or 27½ per cent. under the same conditions of boiler, distance, &c.

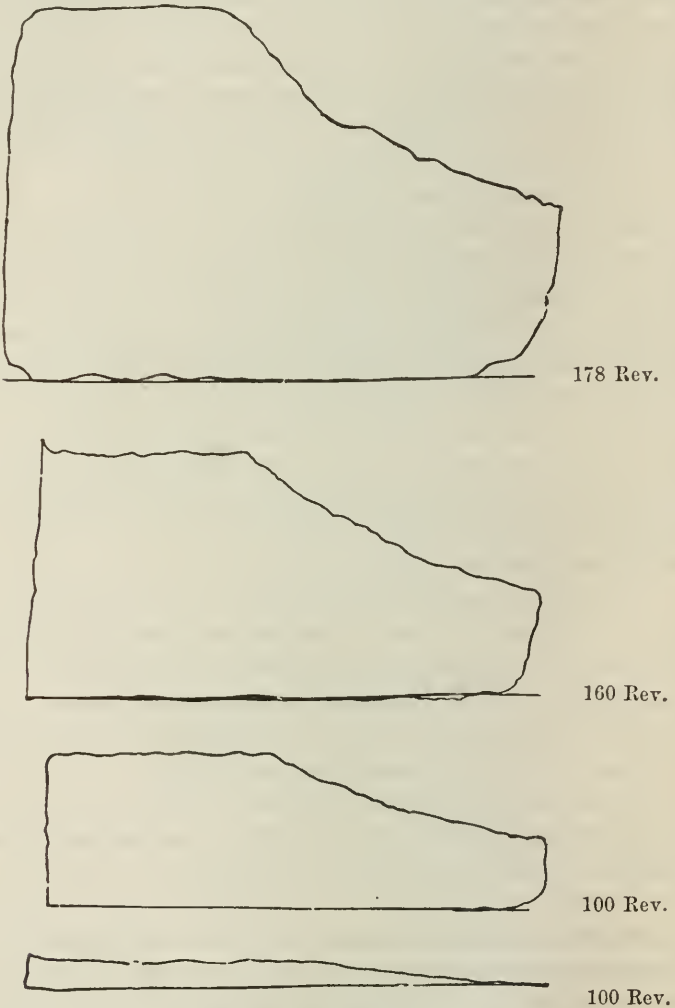
6. *Lubrication and Packing.*—The actual record of the engine examined showed an average cost of six (6) cents per day for the five preceding months (half a pound of tallow per day), or not over one-fifth the cost of lubricating the ordinary engine. Packing is entirely dispensed with, except a metallic wedge for spreading the pistons to a perfect contact with the cylinders.

7. *Care and Attendance.*—As the working parts are all under cover, and one lubrication will usually last for ten hours, the attendance required is necessarily very slight.

8. *Friction and Effective Power.*—The indicator cards taken by me, as given below, show that the power absorbed by this engine to overcome friction amounted to only 21.100 horse-power, or one and one-third per cent. of the nominal power of the machine. This is the most astonishing result in my experience, and I will let the figures carry their own inference. In my opinion, the friction varies in an almost infinitesimal degree under 1 or 100 pounds pressure

of steam, as the pressure is at an opposite angle from the wearing surface of the piston, and does not sensibly affect it.

As to the power of which this engine is capable, I will add some of the diagrams taken by me for the Board of Judges, all of which were the most absolutely perfect of any indicator cards I have ever seen taken from any engine.



Scale, 30 pounds to the Inch.

These diagrams were taken from an engine of the manufacturers' ordinary construction, such as they offer for their regular sales.

The piston area of the engine equals that of the usual double-acting engine of $8\frac{1}{2}$ cylinder.

MARK B. HORNE,
*Engineer Merrimack Print Works.*

We also have received from Mr. Charles D. Kellogg the following account of a test with a dynamometer, made upon the same engine tested by Mr. Horne as above.

This test was made a few days since by Isaac Newton, Esq., late Engineer U. S. N., and the Chief Engineer of the *first Monitor*, when she went out to fight the Merrimac. The result was as follows, viz: 116 pounds were held up on the end of a lever 60 inches long, resting on a pulley 20 inches diameter, running 200 revolutions per minute, 80 pounds boiler pressure of steam; 116 pounds at 60 in. $= 696$ pounds at 10 in. or $\frac{1}{2}$ diameter of pulley; speed, 20 in. $\times 3 + = 60 +$ in. or $5{\cdot}236$ feet $\times 200 = 1047{\cdot}2$ feet per minute; $696 \times 1047{\cdot}2 = 728{,}851 \div 33{,}000 = 22\frac{08}{100}$ horse-power. This shows the *effective* power of the engine to be nearly equal to the gross estimated power, and that the friction is reduced to minimum. This, in connection with Mr. Horne's card of the engine without work, shows that our engine has far more effective power than any on record.

As to fuel, we average in our own shop, in Newark, $3\frac{2}{3}$ pounds coal per hour per horse-power, on a 6-horse engine, without expansion. A 10-horse engine, cutting off at half stroke, of which exact records have been kept, averages $3\frac{1}{4}$ pounds per hour per horse-power; while a 20-horse engine cutting off at about $\frac{2}{3}$ds, stroke, at work in a grist mill, in Salem, Mass., is run with $2\frac{86}{100}$ pounds per hour per horse-power, without deductions for starting or drawing the fires. The same engine grinds nearly 50 per cent. more fine meal per hour per horse-power, than any engine builders in New England are willing to guarantee for their engines.

These tests speak most highly for the machine, and in connection with the general opinion of users which has reached us, has very great weight.

**Magneto-Electric Telegraph.**—A small magneto-electric machine has been successfully applied in Paris to operate a telegraphic line from Metz.

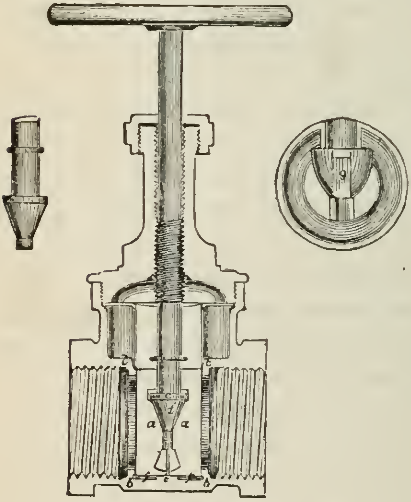
**The Suez Canal** has now been opened for vessels of light burden. Two schooners, some time since, passed through. One was French, the *Luzette*, the other Greek, the *Phaneroman*.

**The Peet Valve.**—At the last meeting of the Institute, there was exhibited this stop-valve, which is the only one of an efficient character yet furnished; which gives a straight and unobstructed passage to the flow of steam, water, or gas, which it controls.

The general structure of this valve is shown by the cut. It consists of a pair of sliding disk-plates, accurately fitted to two flat seats in the sides of the valve.

These disks are suspended and hang loosely on a collar on the stem. The end of the stem is a conical wedge; when the disks strike the bottom of the shell, this wedge is forced by the screw and hand-wheel between them, which presses them asunder, and thus drives each home on its seat.

At this point a slight turn of the wheel closes the valve *perfectly;* with a slight reverse of the hand-wheel it is entirely freed and opens without friction or resistance. This valve is equally effective against the pressure from either way, and the pressure which tends to open one side closes the other.



It has two joints, which makes it twice as effective and more than twice as durable as any single-jointed valve. For instance, a single particle of dust in the seat of a single-jointed valve causes a leak; a few hours makes that leak a permanent one. A single grain of dust in one seat of the Peet Valve would not cause a leak without the remarkable coincidence of another particle at the same time on the other seat.

This valve can always be packed under pressure of steam or water; it is machine-made throughout, every part being interchangeable, and made of the best steam metal.

The joints of this valve evidently are not effected by expansion or contraction, since any change of size in the disk or seat would simply cause a slight motion in no way influencing the joint. The joints being again at right-angles to the current passing through, are not exposed to any filing action, as where the fluid travels across the valve-face.

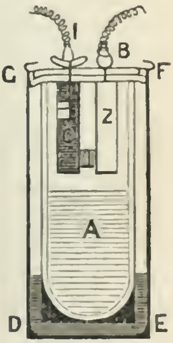
The disks can be duplicated at a trifling cost, and, the valve-faces and seats being *flat*, can always be *perfectly* repaired.

Being perfectly symmetrical, either end may be an *inlet*, and its shell is capable of resisting all ordinary strain.

The valves exhibited on the occasion above mentioned, were sent by Messrs. Foreman & Battles, 24 North Sixth street, Philadelphia, agents for the State of Pennsylvania, and were made by the American Tool Company of Boston.

**New Portable Battery,** by C. T. Chester, New York.—At a late meeting of the Franklin Institute, there was exhibited and described, by means of diagrams, a new form of carbon Smee battery, which is eminently fitted for transportation, and for use in locations where any escape of acid would be highly objectionable.

The accompanying cut will give some idea of its principle. A short test-tube or like vessel contains the dilute sulphuric acid or acid sulphate of mercury, A, which is employed as an exciting fluid, and is closed at top by a zinc cover, F G, having a piece of soft rubber beneath it to secure a tight joint, and held in place by an elastic band attached to hooks or lugs, F G, and passing under a block, E D, in which the tube or vessel is set. The elements, zinc and carbon, are suspended from the cover, the carbon being insulated by a rubber washer. The connections between successive cells are made by spiral springs of brass wire, I, which are thrust over rounded conical points attached to each element, as shown in the cut. The elements do not enter the liquid when the cell is in an erect position, but action is established by inverting the apparatus. A battery of ninety-five such cells was exhibited on the occasion mentioned, and was found to operate in the most satisfactory manner. In connection with various telegraphic instruments it produces remarkable effects, and in medical use occasions contractions that no induced current will produce.



**Explosion of an Oxygen Reservoir.**—We have just received from Dr. Wilkinson of New York, who is associated with Dr. Doremus in the preparation and arrangement of his impressive experiments, the following account, which he was kind enough to furnish in answer to inquiries which we made when preparing an account of the fatal explosion in West Philadelphia. (See page 4.) Dr. Wilkinson's letter did not reach us until the above notice had been printed, and could not therefore be given in connection with it, as we should have wished; but will be of no less interest and value to all concerned in such manipulations. We quote from the Doctor's letter, the portion having reference to this subject. He says:—

"The explosion to which you refer occurred in this way. We at the time employed a large copper flask of some four quarts capacity, in which was placed two or three pounds of the oxygen mixture; the cap secured tightly, then placed on a furnace on a bed of hot coals, an India rubber tube attaching it to a bag of the same material. It took some time before the gas commenced to make. When it did commence, the flask was red-hot; then it came off freely; but just as it was about ceasing, a tremendous explosion occurred, throwing a large twelve-feet table to the ceiling, smashing every pane of glass in the laboratory, bursting open all the doors, and last, not least, throwing Mr. Zincker, who was alone at the time in the room, through a door into an adjoining room, where he says he recovered himself, and immediately looked for his spectacles, which to this day have not been found. That an explosive mixture was formed, he has not a particle of doubt; but as to its exact composition, he has not made up his mind. I have often made oxygen in a glass flask, using a flexible tube to convey it to the jars without any bad results following. But when a metallic flask is used, and heat applied freely, the gas passed directly into the bags, the condition of things are quite different; under such circumstances the gas gets a temperature of nearly 1100°, sufficient to decompose the hydro-carbon of which the bags are composed. Passing the gas through a wash-bottle would prevent any such accident; at any rate, I know of those that have made thousands of feet without any difficulty." In conversation with Mr. S. N. Ritchie, of Boston, we heard of two similar cases in his experience.

**Artificial Grindstones** of excellent quality and even texture are now manufactured from Ransom's patent concrete. Indeed, in some respects, these manufactured stones are preferable to the best Yorkshire and Durham stones. Any degree of fineness and sharpness of grit may be made, according to the materials selected. They are perfectly smooth, and have no hard spots, as the best of natural stones are apt to have. Some extraordinary results of experiments are recorded in a late number of *Mechanics' Magazine*; but we prefer to see some further proofs, before accepting these as facts. Thus a pair of Mr. Ransom's artificial grindstones were tested against a pair of New Castle stones under similar conditions, and the results afterwards compared. A bar of steel three-quarters of an inch in diameter was kept constantly up to the face of the grindstone by means of a spring; the artificial stone was first tried and a quarter of an ounce of steel was ground away in sixteen minutes. The steel and tube were then fixed to the New Castle stone, which had a surface speed 20 per cent. greater than the other; here eleven hours were occupied in grinding away the same weight of steel (a quarter of an ounce) as the artificial stone ground off in sixteen minutes. This (counting the extra speed of the New Castle stone) is in a proportion of about 1 to 52.

**Paraffine for Oiling at a High Temperature,** by M. A. Monet. In the number of *Cosmos* just received, we find an article which we think well worth translating in abstract for our readers.

The oiling of machines at high temperatures, when these, for example, are above 200°, presents a great difficulty. The oils or lubricants at present in use are decomposed by the heat, and leave a residue or coating often as thick as varnish and very sticky, the adherence of which on the sides of the cylinder hinders the movement of the piston; or, to say the least of it, this coating does not perform the function of a lubricator, and packing for the capillary spaces.

In hot-air machines on the plan of Errickson, and the like, it becomes impossible fully to attain the limit at which the metallic pieces are still sufficiently strong, since it is impossible to lubricate them. When the oily materials are thick and changed, the rubbing parts adhere, and cut against themselves under the force of the pressure.

The problem then is to find a lubricating substance unalterable at 300° or 400°, and cheap enough to be employed on a large scale.

The class of paraffines furnish a substance called *mèlène* ($C^{30}$ $H^{60}$) insoluble in water, soluble in the fixed oils, volatile without decomposition, and not boiling under 370°, and at the ordinary temperature it is of the consistency of wax, and floats on the surface of cold water. Paraffine has long been known as an infallible preservative of metals against oxidation. It is an excellent preservative on brass-work, protecting it from the ravages of rust, verdigris, or the moisture from handling.

**A New Anæsthetic.**—Dr. Richardson has lately given to the world a new and valuable substance whereby anæsthesia may be produced without the risk which has hitherto attended the use of chloroform. This substance is the bichloride of methylene. It is stated that no pain attends its use, and the effects are produced in a very short space of time. Perfect insensibility was produced in one case in four minutes, and another in six minutes.

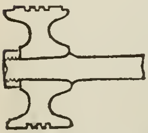
**A New Railroad** has been authorized by the Emperor of Brazil to be constructed. The road will have its terminus in the city of the Rio Grande de Sue, and is expected to reach the coal regions in the interior of the empire.

**Waste Coal Dust** has lately been utilized in this country as fuel, by injecting it by means of a current of compressed air into the space over the fire, where it is said to burn with an intensely hot flame.

**The Supply of Pure Water for London.**—This question has of late been engaging much attention among engineers. One of the plans proposed lately, is that of sinking about fifty artesian wells in different parts of the city, on the vertebraical principle. It is supposed that at a distance of 600 yards down, there is an unlimited supply of water. The estimated cost of the work of constructing these fifty wells is $5,000,000, and it is calculated that each well will raise and distribute four million gallons per day of twenty-four hours.

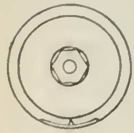
**Self-adjusting Piston.**—We have received from Mr. Wm. A. Sweet, of the firm of Sweet, Barnes & Co., the following description:—In the construction of this piston I adopted this plan:—I bored the cylinder as perfect as I could, then fitted the piston as tight as two men could move it; then set a heavy sharp tool in the lathe, and carried the point against the face of the piston. Now I had the piston taken to a kettle of boiling water, and plunged in and left there, until I was satisfied that it had obtained the temperature of the water. Then took it to the lathe, and put it in and started a chip as soon as it could be done; this gave me the size of the piston. I then let the piston get cold, or the same temperature as the cylinder; set the tool forward, and turned the piston off. This leaves the solid piston as large as I think is safe to leave it. The bronze rings I make $\frac{3}{8}$-inch for a 12-inch piston. This I have adopted as a standard proportion, increasing $\frac{1}{32}$ for an inch for one inch diameter of cylin-

Fig. 1.



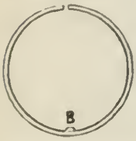
der. The steam space, A, Fig. 2, will let the steam under the piston, and help carry the weight of the piston from the bottom of the cylinder, and the little knob, B, Fig. 3, keeps the rings from working round.

Fig. 2.



The advantage of this piston is, that your engineer has nothing to meddle with. The same ring casting will make two sets of these rings, and they can be fitted to a solid calliper, and are ready to step in at any time in a few minutes. From my experience thus far, I think one set will last one year without any appreciable wear of the cylinder. I believe the Ramsbottom piston is the best now in use; unless it is those which I have made and introduced, the technical improvements of which I have described.

Fig. 3.



# Editorial Correspondence.

## NEW RAPID TELEGRAPH.

The Abbé Moigno, who for many years contributed largely, as co-editor, to the usefulness and success of the *Cosmos*, has lately accepted an engagement as regular Paris Correspondent to the English *Chemical News*. His letters to that Journal display alike his excellent command of our language and extensive connection with all that is going on in the wide field of scientific novelty. It is thus with peculiar pleasure that we have received from him a letter for the *Journal*, which he proposes to follow up with others from time to time.—Editor.

Paris, *December 28th*, 1867.

Since the 11th September, 1867, the administration of the French telegraphic lines uses, for its service between Paris and Lyons, a new system of rapidly telegraphing, the invention of M. M. Chaurapaignes and Lambrig, telegraph assistants.

This telegraph acts automatically, transmitting despatches between two towns at the rate of 120 to 180 despatches per hour, by a single conducting wire, a velocity already equal to three times that of other telegraphs, and capable of being augmented proportionally to the diameter of the conductor.

The transmissions are made by means of a band of metallic paper on which the signals composing the despatch are traced with insulating ink. The reproduction is obtained on a band of unsized paper, the middle portion of which is impregnated with a chemical liquor, necessary for the formation of the signs existing on the metallic band.

In order to obtain regularity of execution, the work, such as the composition, transmission, and reception, is divided among a certain number of hands, according to requirement.

One and the same instrument in communication with the line, is composed of—

1. A clock-work movement; 2. A double roller, which draws either the metallic band or the chemical one; 3. A ringing apparatus for warning the corresponding clerk; 4. A Morse manipulator or key of ordinary construction.

The clock-work is put in movement by a weight which is wound up by a crank; it sets the rollers in motion.

Near the roller on which the metallic band passes, is a point which represents the extremity of the conducting wire. The roller communicates with an electric battery. When the band is drawn by the roller, the point is sometimes on the metallic portions of the band, and sometimes on the surfaces containing the writing of the despatch in insulating ink, thus producing emissions and cessations of the current, according to the signification of the message.

Near the roller, where the band of unsized paper passes, there is a small cup filled with a liquor composed of water, nitrate of ammonia and ferro-cyanide of potassium. In the midst of this cup is placed a small roller, which dips into the cup by its lower portion. The upper portion is a little higher than the edges of the cup, and thus supports the band of unsized paper, which, being drawn by the rollers, causes the little roller to revolve in the cup, and to leave on the paper a thin film for the reproduction of the signals when the current passes. This film extends through the paper immediately, and disappears immediately.

An iron point, representing, as that of the metallic band, the extremity of the line, rests by its own weight, slightly inclined, upon the fillet in communication with the earth, the electric current decomposes the humid portion and leaves a colored deposit, which represents the signals of the despatch.

The working of this instrument is so simple and self-acting, that one clerk can manage it perfectly without fatigue. He can prepare from thirty-five to forty despatches per hour; the assistants acquainted with the Morse instrument can compose the despatches. For the composition of the transmission between Paris and Lyons, three composing clerks are sufficient.

We have received the following communication from M. Bertsch, of Paris, relative to a note, inserted in the *Mondes* of the 21st November, from Mr. Morton, of Philadelphia; an extract will suffice:—

"M. Morton, après avoir observé, comme beaucoup de physiciens, que dans la machine de Holtz, telle que la construit M. Ruhmkorff, le courant va en s' affaiblissant pour cesser tout à fait au bout de quelques semaines, a cru reconnaître que l' amoindrissement graduel des effets devait être attribué à un decollement partiel des bords des armatures. En conséquence a fractionnel le plateau fixe pour pouvoir aisément, dit il, en changer les différents segments lorsque la machine ne fonctionne plus, &c."

Mr. Morton, after having observed, as many physicists have done, that, in the Holtz machine as constructed by Mr. Ruhmkorff, the current decreases gradually, and then ceases altogether at the end of a few weeks, thinks that the gradual decrease of the effects must be attributed to a loss of insulation occurring at the edges of the armatures. Consequently, he has divided the fixed plate, in order, says Mr. Morton, to exchange the different segments when the machine will no longer work. It is only necessary to glance at the details of this construction and the figures accompanying the note, to see that it enormously complicates the organs of the machine so elegantly and skillfully combined by Mr. Ruhmkorff. Mr. Morton does not seem to me to have remedied the inconvenience, more apparent than real, which is avoided, in the meantime, while preserving the excellent dispositions of the machine.

The weakening of the current cannot be attributed to the cause assigned by Mr. Morton. It depends on a superficial modification of the surfaces in front of each other. The disks covered with shellac get covered gradually with organic matter, which in inhabited places soon tarnishes all polished bodies, such as glass, mirrors, &c.

Under the progressive influence of this sufficiently conducting surface, the rotating plate ceases by degrees to become polarized. It becomes electrified by taking a portion of the charge from the armatures; on the other hand, these latter, from the same cause, communicate between each other by means of the fixed plate, which has become a conductor, and which causes a current to be established, and the machine stops. The simplest remedy for this, is to pass between the isolating surfaces a pad of soft paper, imbibed with a few drops of turpentine, naphtha oil, benzine, or petroleum oil, so as to restore all its energy to this curious machine.

F. MOIGNO.

We are very far from wishing to take any advantage of our position, as nearer to our readers, to depreciate the arguments or ability of M. Bertsch, whose reasons have been repeated as above by our learned correspondent. Mr. Bertsch, as will be seen by reference to this *Journal*, Vol. LIII., page 36, is the author of one of the first and most admirable improvements on the Holtz machine, and is thoroughly conversant with its theory. In the present case, we think he is, however, hasty in his conclusions. The drawings to which he refers are those representing the modified forms of the Holtz machine made by Mr. Chester and Mr. Ritchie and published in the *Journal*, Vol. LIII., pp. 253 and 344, and which we afterwards sent, with the note or description mentioned, to *Les Mondes*. The drawings might naturally suggest to one inspecting them for the first time the idea of complication. But we, who have the advantage over M. Bertsch, that we have in our own possession both forms of the machine (that of Ruhmkorff and the new American modification), find, from absolute use and experience, that the latter is not only infinitely more easy to manage, but is likewise far cheaper and more simple in construction. Cutting the stationary plate into four, makes, to be sure, four pieces in place of one; but as these four need but one support apiece, and the entire plate required four, nothing is lost here, while, on the contrary, a great gain is secured with reference to other parts, and the facility of renewal.

As regards the remedy suggested by M. Bertsch, we sincerely wish that it were effective. It is the plan advised by the inventor in his first description, and we tried it at once, when our machine, made by Ruhmkorff, first failed, but without effect.

The varnishing of the edge of the paper, however, we have repeatedly found most efficient. This, however, only shows that there are certain conditions not yet fully understood which have a great influence. We do not for a moment doubt that the cleaning process has succeded with M. Bertsch; but as it certainly fails with our apparatus, it is well to bear both remedies in mind.

# Civil and Mechanical Engineering.

## ON THE ADHESION OF LEATHER BELTS TO CAST IRON PULLEYS.

By Henry R. Towne.

The following experiments, undertaken at the instance of Mr. Robert Briggs, had for their object to determine, in a satisfactory and conclusive manner, the true value of the co-efficient of friction of leather belts on cast iron pulleys. This result has, it is hoped, been attained, and in the January number of this *Journal* Mr. Briggs has discussed at length the theory of the action of belts, and has also given practical formulæ in which the co-efficient of friction employed is that deduced from these experiments, which latter have been made with great care, and may, it is believed, be accepted as reliable. In order, however, that all interested may judge for themselves of the correctness of the deductions made from them, we present herewith a complete tabular record of the experiments, which will also repay examination as exhibiting several interesting and instructive facts connected with the efficiency of leather belts.

The experiments were made with leather belts of three and six inches width and of the usual thickness—about $\frac{3}{16}$ths of an inch. The pulleys used were respectively of 12, $23\frac{5}{8}$, and 41 inches diameter, and were in each case fast upon their shafts. They were the ordinary cast iron pulleys, turned on the face, and, having already been in use for some years, were fair representatives of the pulleys usually found in practice.

Experiments were made first with a perfectly new belt, then with one partially used and in the best working condition, and, finally, with an old one, one which had been so long in use as to have deteriorated considerably, although not yet entirely worn out. The adhesion of the belts to the pulleys was not in any way influenced by the use of unguents or by wetting them;—the new ones when used were just in the condition in which they were purchased—the others in the usual working condition of belts as found in machine shops and factories—that is, they had been well greased and were soft and pliable.

The manner in which the experiments were made was as follows:—The belt being suspended over the pulley, in the middle of its length, weights were attached to *one* side of the belt, and increased until the latter slipped freely over the pulley; the final, or *slipping* weight, was then recorded. Next, 5 lbs. were suspended on *each* side of the belt, and the additional weight required upon *one* side to produce slipping ascertained as before, and recorded. This operation was repeated with 10, 20, 30, 40, and 50 lbs., successively, suspended upon both sides of the belt. In the tables these weights, *plus* half the total weight of the belt, are given as the "equalizing weights" ($T_2$ in the formulæ), and the *additional* weight required upon one side to produce slipping, is given under the head of "unbalanced weights;" this latter, *plus* the equalizing weight, gives the total tension on the loaded side of the belt ($T_1$ in the formulæ).

The belt, in slipping over the pulley, moved at the rate of about 200 feet per minute, and with a constant, rather than increasing, velocity; or, in other words, the final weight was such as to cause the belt to slip smoothly over the pulley, but not sufficient to entirely overcome the friction tending to keep the belt in a state of rest. In this case (*i.e.* with an excessive weight) the velocity of the belt would have approximated to that of a falling body, while in the experiments its velocity was much slower, and was nearly constant, the friction acting precisely as a brake. By being careful that the final weight was such as to produce about the same velocity of the slipping belt in all of the experiments, reliable results were obtained.

It became necessary to make use of a weight such as would produce the positive motion of the belt described above, as it was found impossible to obtain any uniformity in the results when the attempt was made to ascertain the minimum weight which would cause the belt to slip. With much smaller weights *some* slipping took place, but it was almost inappreciable, and could only be noticed after the weight had hung for some minutes, and was due very probably to the imperceptible jarring of the building. After essaying for some time to conduct the experiments in this way, and obtaining only conflicting and unsatisfactory results, the attempt was abandoned, and the experiments made as first described.

In this way, as may be seen, results were obtained which compare together very favorably, and which contain only such discrepancies as will always be manifest in experiments of the kind. It is only by making a great number of trials and averaging their results, that reliable data can be obtained.

The value of the co-efficient of friction which we deduce from our experiments, is the mean of no less than one hundred and sixty-eight distinct trials.

It will noticed, however, that the co-efficient employed in the formulæ is but *six-tenths* of the full value of that deduced from the experiments, the latter being 0·5853 and the former 0·4229. This reduction was made, after careful consideration, to compensate for the excess of weight employed in the experiments over that which would just produce slipping of the belt, and may be regarded as safe and reliable in practice.

A note is made, over the record of each trial, as to the condition of the weather at the time of making it—whether dry, damp, or wet,—and it will be noticed that the adhesion of the belts to the pulleys was much affected by the amount of moisture in the atmosphere. It is to be regretted that this contingency was not provided for, and a careful record of the condition of the atmosphere kept by means of an hygrometer. The experiments indicate clearly, however, that the adhesion of the old and the partially-used belts was much increased in damp weather, and that they were then in their maximum state of efficiency. With the new belts the indications are not so positive; but their efficiency seems to have been greatest when the atmosphere was in a dry condition.

Experiments were also made upon the tensile strength of belts, with the following results:—The weakest parts of an ordinary belt are the ends through which the lacing holes are punched, and the belt is usually weaker here than the lacing itself. The next weakest points are the *splices* of the several pieces of leather which compose the belt, and which are here perforated by the holes for the copper rivets. The strengths of the new and the partially used belts were found to be almost identical. The average of the trials is as follows:—

| | |
|---|---|
| Three-inch belts broke through the lace holes with ...... | 629 pounds. |
| " " " " rivet " ...... | 1146 " |
| " " " " solid part " ...... | 2025 " |

These give as the strength *per inch of width.*

| | |
|---|---|
| When the rupture is through the lace holes.................. | 210 pounds. |
| " " " " rivet " .................. | 382 " |
| " " " " solid part.................. | 675 " |

The thickness being $\frac{7}{32}$ inch (=·219), we have as the tensile strength of the leather 3086 lbs. per square inch.

From the above we see, that 200 lbs. per inch of width is the ultimate resistance to tearing that we can expect from ordinary belts.

The experiments herein described are strikingly corroborative of those already on record, and this gives increased assurance of their reliability, and, although there is nothing novel either in them or in their results, it is hoped that they will prove of interest, and that an examination of them will lead to confidence in the formulæ which are based upon them.

## THREE-INCH NEW BELT.

| ON 12-INCH PULLEY (BETWEEN SEAMS). | | | | | | ON 12-INCH PULLEY (ON SEAMS). | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| Equalizing weights, or initial tension on each side of belt $T_2$. | Unbalanced weight—Trial No. 1. | Unbalanced weight—Trial No. 2. | Unbalanced weight—Average of trials. | Total weight on loaded side of belt when belt slipped $= T_1$. | $T_1 \mid T_2$ | Equalizing weights, or initial tension on each side of belt $= T_2$. | Unbalanced weight—Trial No. 1. | Unbalanced weight—Trial No. 2. | Unbalanced weight—Average of trials. | Total weight on loaded side of belt when belt slipped $= T_1$. | $T_1 \mid T_2$ |
| | Damp. | Dry. | | | | | Damp. | Damp. | | | |
| 2·94 | 17 | 20 | 18·5 | 21·44 | 7·29 | 2·94 | 14 | 14 | 14·0 | 16·94 | 5·76 |
| 7·94 | 43 | 58 | 50·5 | 58·44 | 7·36 | 7·94 | 30 | 32 | 31·0 | 38 94 | 4·90 |
| 12·94 | 70 | 86 | 78·0 | 90·94 | 7·03 | 12·94 | 48 | 51 | 49·5 | 62·44 | 4·83 |
| 22·94 | 108 | 167 | 137·5 | 160·44 | 6·99 | 22 94 | 92 | 87 | 89·5 | 112·44 | 4·90 |
| 32·94 | 124 | 226 | 175·0 | 207·94 | 6·31 | 32·94 | 107 | 110 | 108·5 | 141·44 | 4·29 |
| 42·94 | 159 | 311 | 235·0 | 277·94 | 6·47 | 42·94 | 134 | 138 | 136 0 | 178·94 | 4·17 |
| 52·94 | 210 | 343 | 276·5 | 329·44 | 6·22 | 52·94 | 191 | 188 | 189·5 | 242 44 | 4·58 |
| Mean. | | | | | 6·810 | Mean. | | | | | 4·775 |

THREE-INCH NEW BELT.

| ON 23⅝-INCH PULLEY. | | | | | | ON 41-INCH PULLEY. | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| Equalizing weights, or initial tension on each side of belt = $T_2$. | Unbalanced weight—Trial No. 1. | Unbalanced weight—Trial No. 2. | Unbalanced weight—Average of trials. | Total weight on loaded side of belt when belt slipped = $T_1$. | $\frac{T_1}{T_2}$ | Equalizing weights, or initial tension on each side of belt = $T_2$. | Unbalanced weight—Trial No. 1. | Unbalanced weight—Trial No. 2. | Unbalanced weight—Average of trials. | Total weight on loaded side of belt when belt slipped = $T_1$. | $\frac{T_1}{T_2}$ |
| | Damp. | Damp. | | | | | Dry. | Dry. | | | |
| 2·94 | 12 | 16 | 14·0 | 16·94 | 5·76 | 2·94 | 13 | 13 | 13·0 | 15·94 | 5·42 |
| 7·94 | 34 | 44 | 39·0 | 46·94 | 5·91 | 7·94 | 38 | 39 | 38·5 | 46·44 | 5·85 |
| 12·94 | 54 | 77 | 65·5 | 78·44 | 6·06 | 12·94 | 55 | 61 | 58·0 | 70·94 | 5·48 |
| 22·94 | 110 | 135 | 122·5 | 145·44 | 6·34 | 22·94 | ……… | ……… | ……… | ……… | ……… |
| 32·94 | 161 | 191 | 176·0 | 208·94 | 6·34 | 32·94 | 188 | 176 | 182.0 | 214·94 | 6·53 |
| 42·94 | 207 | 234 | 220·5 | 263·44 | 6·14 | 42·94 | ……… | ……… | ……… | ……… | ……… |
| 52·94 | 277 | 282 | 279·5 | 332·44 | 6·28 | 52·94 | 289 | 295 | 292·0 | 344·94 | 6·52 |
| Mean……… | | | | | 6·118 | Mean……… | | | | | 5·960 |

THREE-INCH BELT.

| PARTIALLY USED AND IN GOOD ORDER—ON 12-INCH PULLEY. | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| Equalizing weight, or initial tension on each side of belt = $T_2$. | Unbalanced weight—Trial No. 1. | Unbalanced weight—Trial No. 2. | Unbalanced weight—Trial No. 3. | Unbalanced weight—Trial No. 4. | Unbalanced weight—Trial No. 5. | Unbalanced weight—Average of trials. | Total weight on loaded side of belt when belt slipped = $T_1$. | $T_1 \mid T_2$ |
| | Damp. | Damp. | Wet. | Dry. | Dry. | | | |
| 3·2 | 13 | 14 | 26 | 12 | 11 | 15·5 | 18·7 | 5·84 |
| 8·2 | 34 | 36 | 53 | 32 | 32 | 37·4 | 45·6 | 5·56 |
| 13·2 | 57 | 63 | 77 | 50 | 50 | 59·4 | 72·6 | 5 50 |
| 23·2 | 102 | 109 | 149 | 90 | 99 | 109·8 | 133·0 | 5·73 |
| 33·2 | 123 | 128 | 226 | 144 | 144 | 153·0 | 186·2 | 5·61 |
| 43·2 | 174 | 185 | 299 | 183 | .................. | 210·2 | 253·4 | 5·87 |
| 53·2 | 226 | 265 | 338 | 249 | .................. | 268·5 | 322 7 | 6·07 |
| Mean.................. | .................. | .................. | .................. | .................. | .................. | .................. | .................. | 5·754 |

## THREE-INCH BELT—PARTIALLY USED AND IN GOOD ORDER.

| ON 41-INCH PULLEY. | | | | | | ON 23⅝-INCH PULLEY. | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Equalizing weights, or initial tension on each side of belt = $T_2$. | Unbalanced weight—Trial No. 1. | Unbalanced weight—Trial No. 2. | Unbalanced weight—Average of trials. | Total weight on loaded side of belt when belt slipped = $T_2$. | $\frac{T_1}{T_2}$ | Equalizing weights, or initial tension on each side of belt = $T_2$. | Unbalanced weight—Trial No. 1. | Unbalanced weight—Trial No. 2. | Unbalanced weight—Trial No. 3. | Unbalanced weight—Average of trials. | Total weight on loaded side of belt when belt slipped = $T_1$. | $\frac{T_1}{T_2}$ |
| | Dry. | Dry. | | | | | Damp. | Damp. | Dry. | | | |
| 3·2 | 26 | 25 | 25·5 | 28·7 | 8·97 | 3·2 | 23 | 22 | 23 | 22·6 | 25·8 | 8·06 |
| 8·2 | 59 | 55 | 57·0 | 65·2 | 7·95 | 8·2 | 53 | 54 | 53 | 53·3 | 61·5 | 7·50 |
| 13·2 | 86 | 82 | 84·0 | 97·2 | 7·36 | 13·2 | 86 | 89 | 82 | 85·6 | 98·8 | 7·48 |
| 23·2 | …… | …… | …… | …… | …… | 23·2 | …… | …… | 141 | …… | …… | …… |
| 33·2 | 188 | 194 | 190·5 | 223·7 | 6·74 | 33·2 | 194 | 210 | 181 | 195·0 | 228·2 | 6·87 |
| 43·2 | …… | …… | …… | …… | …… | 43·2 | …… | …… | 223 | …… | …… | …… |
| 53·2 | 306 | 323 | 314·5 | 367·7 | 6·91 | 53·2 | 285 | 316 | 272 | 291·0 | 344·2 | 6·47 |
| Mean…… | | | | | 7·586 | Mean…… | | | | | | 7·276 |

THREE-INCH OLD BELT.

| ON 12-INCH PULLEY. | | | | | | ON $23\frac{5}{8}$-INCH PULLEY. | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| Equalizing weights, or initial tension on each side of belt = $T_2$. | Unbalanced weight—Trial No. 1. | Unbalanced weight—Trial No. 2. | Unbalanced weight—Average of trials. | Total weight on loaded side of belt when belt slipped = $T_1$. | $\frac{T_1}{T_2}$ | Equalizing weights, or initial tension on each side of belt = $T_2$. | Unbalanced weight—Trial No. 1. | Unbalanced weight—Trial No. 2. | Unbalanced weight—Average of Trials. | Total weight on loaded side of belt when belt slipped = $T_1$. | $\frac{T_1}{T_2}$ |
| | Damp. | Damp. | | | | | Damp. | Wet. | | | |
| 2·75 | 12 | 13 | 12·5 | 15·25 | 5·55 | 2·75 | 16 | 20 | 18 0 | 20·75 | 7·55 |
| 7·75 | 35 | 39 | 37·0 | 44·75 | 5·77 | 7·75 | 48 | 70 | 59·0 | 66·75 | 8·61 |
| 12 75 | 61 | 66 | 63·5 | 76·25 | 5·98 | 12·75 | 72 | 106 | 89·0 | 101·75 | 7·98 |
| 22·75 | 102 | 109 | 105·5 | 128·25 | 5·64 | 22·75 | 157 | 174 | 165·5 | 188 25 | 8·27 |
| 32·75 | 142 | 158 | 150·0 | 182·75 | 5·58 | 32·75 | 220 | 232 | 226·0 | 258·75 | 7·90 |
| 42 75 | 203 | 220 | 211·5 | 254·25 | 5·95 | 42·75 | 256 | 276 | 271 0 | 313·75 | 7·34 |
| 52·75 | 259 | 273 | 266·0 | 318·75 | 6·04 | 52·75 | 301 | 311 | 306 0 | 358·75 | 6·80 |
| Mean.................................... | | | | | 5·787 | Mean.................................... | | | | | 7·778 |

SIX-INCH NEW BELT.

| ON 23⅝-INCH PULLEY. | | | | | | ON 41-INCH PULLEY. | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| Equalizing weights, or initial tension on each side of belt = $T_2$. | Unbalanced weight—Trial No. 1. | Unbalanced weight—Trial No. 2. | Unbalanced weight—Average of trials. | Total weight on loaded side of belt when belt slipped = $T_1$. | $\frac{T_1}{T_2}$ | Equalizing weights, or initial tension on each side of belt = $T_2$. | Unbalanced weight—Trial No. 1. | Unbalanced weight—Trial No. 2. | Unbalanced weight—Average of trials. | Total weight on loaded side of belt when belt slipped = $T_1$. | $\frac{T_1}{T_2}$ |
| | Dry. | Damp. | | | | | | | | | |
| 6·75 | 30 | 36 | 33·0 | 39·75 | 5·89 | 6·75 | 32 | 29 | 30·5 | 37·25 | 5·52 |
| 11·75 | 53 | 63 | 58·0 | 67·75 | 5·77 | 11·75 | 53 | 50 | 51·5 | 73·25 | 6·23 |
| 16·75 | 78 | 81 | 79·5 | 96·25 | 5·75 | 16·75 | 72 | 72 | 72·0 | 88·75 | 5·30 |
| 26·75 | 125 | 135 | 130·0 | 156·75 | 5·86 | 26·75 | 118 | 115 | 116·5 | 143·25 | 5·36 |
| 36·75 | 161 | 177 | 169·0 | 205·75 | 5·60 | 36·75 | 159 | 176 | 167·5 | 204·25 | 5·55 |
| 46·75 | 216 | 223 | 219·5 | 266·25 | 5·70 | 46·75 | 209 | 236 | 222·5 | 269·25 | 5·76 |
| 56·75 | 265 | 269 | 267·0 | 323·75 | 5·70 | 56·75 | 265 | 275 | 270·0 | 326·75 | 5·76 |
| Mean.................................................... | | | | | 5·752 | Mean.................................................... | | | | | 5·640 |

# THE SUPPORTING POWER OF PILES, BOTH OF WOOD AND IRON, AND THE USE OF THE LATTER, EITHER AS PILES OR COLUMNS OF SUPPORT FOR FOUNDATIONS.*

A PAPER READ AT THE FRANKLIN INSTITUTE JANUARY 15, 1868. BY HON W. J. McALPINE,
LATE STATE ENGINEER OF NEW YORK, ENGINEER IN CHIEF OF THE U S.
DRY-DOCK AT BROOKLYN, MEMBER OF THE INSTITUTION OF CIVIL
ENGINEERS OF LONDON, MEMBER OF THE FR. INST., &c.

### *Summary.*

The formulæ of Weisbach and Saunders for the sustaining power of wooden piles, widely differ in their applications, made by these authors, of the load which can be safely imposed.

The formula submitted by the author, is based upon numerous experiments made on piles driven into fine sand, of different sizes, different weights of and falls to the ram, and is reliable for piles driven into that kind of material.

The result of these experiments showed, that within certain limits the effect of increasing the weight of the ram was to increase the supporting power in the ratio of ·7 to ·9 of such increased weight; and of increasing the fall was as the square root of such fall; that with piles of the same size, driven by the same weight of ram and fall, but to different depths, the sustaining power was as the squares of their exterior frictional surfaces; and that a pile driven home in fine sand with a ram of one ton falling thirty feet, will sustain one ton for each superficial foot of its friction surface.

Wooden piles are used either to compact the soil, as columns of support, or strictly, as piles—that is, when the support is derived from the exterior frictional surface.

These experiments also demonstrated that, with a given power, considerable advantage was gained by increasing the weight of the ram; but that any increase of the fall beyond 40 feet, in the best made machines, gave no increased penetration, and that quick blows of a heavy ram gave greater penetration at less expenditure of power, as demonstrated by the use of the Nasmyth steam pile-driver.

Experiments made on the sustaining power of the iron columns, considered as piles, at Harlem, showed that they would sustain from

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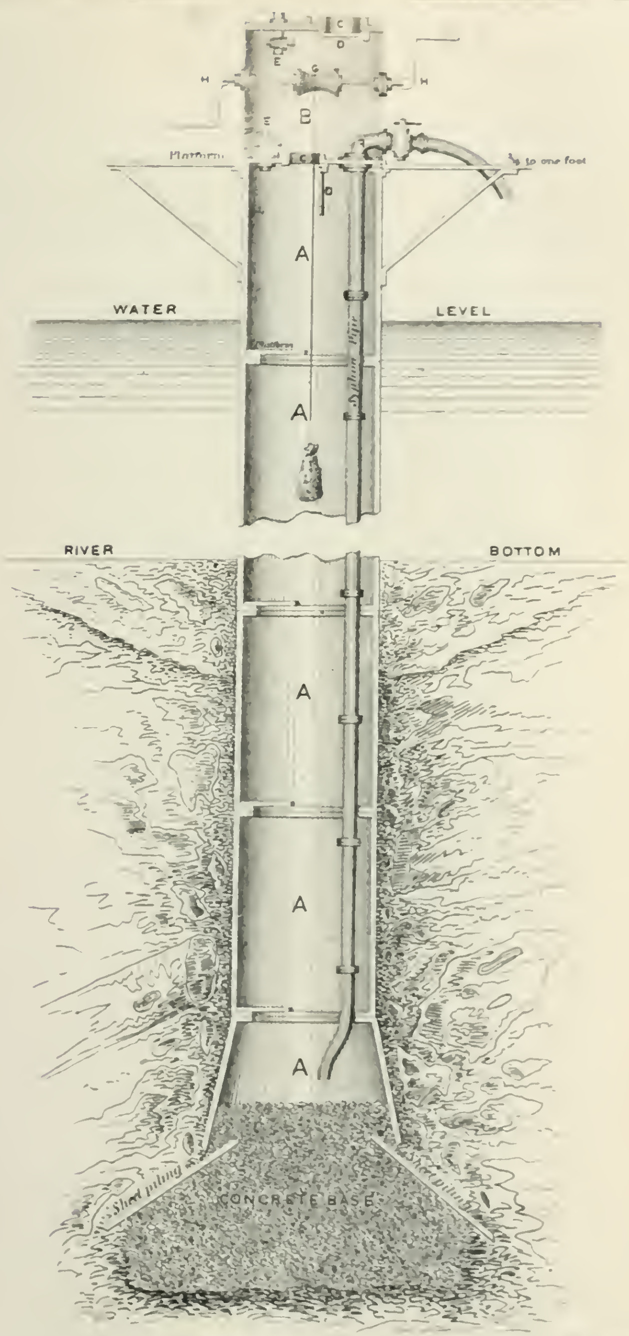
* I have used the term "piles" when the support is mainly derived from the frictional surface in contact with the earth, and the term "columns" when they are driven into an unyielding material which furnishes the chief support.


C
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CONCRETE BASE
Sheet piling

one-half to three-fourths as much per square foot of frictional surface as wooden piles.

The author believes that iron piles or columns may, in certain cases, be substituted for wooden piles with economy, and sometimes that the latter (wooden piles) are inapplicable, when the former meet all the requirements of the engineer.

As an illustration of both of these opinions, he cites the railroad crossings of the large western rivers, and shows that in many cases wooden piles cannot be placed below the probable scour of the stream at any reasonable cost—that is, as compared with the expense of the iron piles—while the latter (the columns), at a moderate cost, will sustain the proposed loads with perfect safety under the deepest and most dangerous scour which has ever occurred under similar conditions.

Such iron piles may be driven when no logs or stone are encountered by the cheaper hydrostatic or excavating processes, and of small diameter, and when such obstacles are encountered, the diameter enlarged will afford the means of quickly and economically removing them by the pneumatic process. Columns of six feet diameter have been driven 25 feet in as many days, through one continued mass of boulders, and in another case through the hull of a vessel, when the wood was in perfect preservation and strongly bolted, with a delay of but two days.

Such iron piles or columns may be driven to any desired depth (even to 100 feet below the surface of the water) at a reasonable cost.

The author has introduced some new expedients in reference to these columns, which at very small cost greatly increases their sustaining power, and another, which materially lessens the cost of driving them.

The former is effected by extending the concrete filling of the columns below and outside of the bottom, and the latter by the use of air reservoirs, which enables the driver to repeat his operations upon the columns at the instant when the surrounding mass of earth is in its most loosened condition.

Doubts have been expressed whether these cast iron piles would not be burst by the severe frost of our climate, and whether the corrosion of the iron would not rapidly weaken and finally destroy them.

Such columns have stood the more severe frost of a Russian winter, and in Scotland as well as Harlem, without the slightest injury, and nowhere does the engineer who studies the question raise this objection. In practice, the columns are sealed at both ends, and no water or moisture can get in to freeze, and if it should it would exert its expansive effort first upon the weaker material (the concrete), while the iron shell, ten times as strong, would be unaffected. The former would be compacted before any dangerous pressure would be produced upon the iron shell.

Soft graphitic iron changes its character in very foul, and slightly so in salt water; but in cast iron, when the carbon is combined, no such change occurs, and only a slight external oxidation takes place, which thereafter serves as a protection.

In fresh water even this corrosion would be inappreciable after the lapse of a century.

American engineers have generally considered this system of foundations unfavorably, from the unnecessarily expensive examples in this country, and the costly methods practised abroad; but also, perhaps, from not regarding the various modifications which may be made in the system to meet the different cases.

The material generally used has been cast iron, for which may be, under certain circumstances, substituted wrought iron, timber, and even plank. The form has generally been cylindrical, but columns of other curves and rectanglar ones may be used.

Generally the cast iron columns have sustained the loads, but the filling (in those of enlarged size) may be of solid cut stone.

The columns may be changed into a combination of diving bells and caissons, so that piers of the ordinary material and form may be founded at great depths with economy and ease, and these bell-caissons may even be made of timber and plank, and used over repeatedly.

The system, in all of its modifications, offers to the appreciative engineer, the means of safely founding his works at a most reasonable cost, and warrants more attention than it has heretofore received in this country.

## ON PILE FOUNDATIONS.

PAPER IN FULL AS READ AT THE FRANKLIN INSTITUTE.

The formula which is generally used to determine the supporting power of wooden piles, is either that of Weisbach or Saunders. In the common range of practice, the results of these two formulæ do not widely differ, but the latter says that his result gives the "safe load," while the former says that "for duration and security such piles are only loaded with from one-tenth to one-hundredth of their strength."

The formula which I have to submit to your consideration is as follows:—

$$P = 80 \cdot (W + .228\sqrt{F} - 1.)$$

Where P represents the extreme supporting power of the pile in tons; W, the weight of the ram in tons, and F the fall of the ram in feet.

This formula was derived from a number of experiments, made upon piles driven for the foundation and coffer-dams of the U. S. Dry-Dock at Brooklyn.

The gentlemen present are doubtless all familiar with the characteristics of that work, and it will only be necessary to state that the structure weighed fifty thousand tons, which had to be supported on an area of forty-four thousand square feet; but the weight could not be equally distributed, and some portions of the foundation had to sustain a weight of three or four tons per square foot.

The material as developed by the excavation, preliminary borings, and subsequent examinations to a depth of sixty feet below the foundation, was a silicious sand mixed with comminuted particles of mica and a little vegetable loam, and was generally encountered in the form of quicksand.

The material into which the foundation piles were driven was nearly uniform in character, which furnished an excellent opportunity of comparing the experiments made at different times, with hammers of different weights and falls.

It may be interesting to state, that the whole number of bearing piles driven for the foundation was 6539 and 1744 sheeting piles, acting in part as supporting piles, which gives nearly 1·7 piles per square yard, or, excluding the sheet piles, 1·4 per square yard.

These piles were chiefly of spruce timber, from twenty-five to forty feet long, and averaged thirty-two feet driven length. They were from twelve to eighteen inches diameter at the head, and never less than seven inches at the foot. They were banded with iron, and occasionally shod, but shoeing produced no increase of penetration.

The average number of blows given to each pile was seventy-three. The average distance moved by the first five blows was eight inches at each blow, by the middle five blows, three inches at each blow, and by the last five blows from two inches to no movement at each blow.

When from any cause the piles went more than an inch at each of the last five blows, another was driven in the centre of the quadrangle, and it was found that this so compacted the material, that the adjacent piles were immovable under the effect of almost any number of blows, of a ton ram, falling thirty feet.

In other words, all of the piles were driven "home," or equivalent to such home driving. The Nasmyth hammer, it is true, produced a deeper penetration of perhaps ten per cent., but under its persuasive powers, the strongest and toughest timbers yielded.

A record was kept of the distance moved by each blow, on every pile used in the structure, and the weight and fall of the hammer.

The piling machines were unusually well made, so as to reduce the friction of the hammer in its fall, and facilitate the operations. The leaders were generally thirty-five feet long, though there was one of fifty-seven feet. The hammers were generally of a ton weight (2240 pounds), but there were some used ranging from a thousand to forty-five hundred pounds.

The experimental piles were selected so as to show the effect of the size of the pile, the weight and fall of the ram, and the rapidity of the blows, as determined by the record before alluded to.

The analysis of these experiments showed the following general laws:—

1. That when the height of the fall of the ram was increased, the sustaining power of the pile (driven home) was increased in the ratio of the square root of the fall.

2. That when the weight of the ram was increased, its effect was to increase the sustaining power of the pile by 0·7 to 0·9 times the amount of the ratio due to such increased weight.

3. That when piles of the same size were driven by the same hammer and from the same height of fall to different depths, their sustaining power was in the ratio of the squares of their frictional surfaces of penetration.

4. That a pile driven home by a hammer of a ton weight, falling thirty feet at the last blows, in such material, would sustain as many tons as there were superficial feet of exterior surface of the pile in contact with the earth, which, however, may be considered as excluding the support due to its sectional area.

The formula above stated is based upon these laws (excluding the third), and the co-efficient is reliable for such material as was found at that place.

It is very desirable that similar experiments should be made in soils of different kinds, which would make this formula applicable to all the usual cases met with in constructions.

I have made experiments elsewhere, but unfortunately they were in soil too nearly similar to the above, to enable me to give any new co-efficients. They served to show the general accuracy of the formula given.

I may here remark, that the circumstances of each particular case must determine how much of the absolute sustaining power should be deducted to show the load which can be safely imposed upon the piles.

When there is no danger from the vibrations of the structure being communicated to the piles, nor from the scouring action of the water, they may be safely loaded with one-third of the weight determined by the formula.

The sustaining power of a pile driven home, the resistance which it meets with, and the force of the blow are, of course, equal. The subsequent subsidence of the material around the pile, however, increases its supporting power, and this varies in different kinds of soil.

This increased support cannot, however, be relied upon, if there is any subsequent vibration in the piles or scour around them.

In foundations under water, there will be a degree of fluidity given to the material by the operation of driving, which lessens the frictional resistance to the penetration of the pile; but the superior gravity of the sand to that of the water, allows it to settle in close contact with the pile, and gives a greater co-efficient of support, than if it was driven through the same kind of material in a dry state.

In comparatively slender elastic wooden piles, the vibrations caused by the blows enlarges the passage and loosens the material in contact with the sides, and although these vibrations absorb a portion of the force of the blow, they probably increase the penetration.

Wooden piles are used under the following conditions, each of which should be separately considered:—

1. To compact a soil which is not quite firm enough alone to support the superstructure.

2. As columns of support, where the material immediately below the structure is very loose, and is underlaid by a firm material; and,

3. Where the support is mainly expected from the adhesion of the adjacent material to the pile.

The first of these conditions need not be here discussed; and in regard to the second, it is only necessary to caution the young engineer that it is one of the most unsafe and dangerous kinds of foundations that he can use.

In concluding this branch of the subject, it may be added, that, with a given power, a considerable advantage is gained by increasing the weight of the ram, and, with a corresponding force of blow, less injury is done to the timber and to the iron rings.

Also, that there is no increased force of blow obtained by a fall of more than forty feet, as the friction on the ways is increased so rapidly that no increased velocity is attained by falling from a greater height. In machines less well made than those at Brooklyn, the limit of useful fall is probably thirty feet or less.

On comparing the results of the Nasmyth machine with those of the ordinary ones, it was observed, that although the force of its blows was much less, the effect was much greater.

With the former, a pile of thirty-five feet length was driven home in seven minutes, while with the other machines, an hour or more was required to drive a similar pile.

The first part of the operation did not exhibit so marked a difference between the two machines as was afterwards shown, while the piles were meeting with greater resistances.

In the first case, the force of the blow in each machine was in part absorbed by the vibrations of that part of the pile above ground; while in the latter, these vibrations, for the instant, removed the partially fluid earth from contact with the pile. The blows of the Nasmyth ram were given at intervals of less than a second of time, and before the material displaced by the vibrations of the preceding blow had had time to subside, and therefore nearly the whole force of its blow was employed in the displacement beneath the pile. In the other machines, the blows were given at intervals of a minute, by which time the vibrations had ceased, and the material had partially subsided around the pile, so that a considerable portion of the force of the blow was consumed in overcoming the friction along the sides, and in the removal by new vibrations, leaving only a comparatively small portion of the force to displace the earth at the bottom.

This effect would probably be produced in nearly all descriptions of earth, although it would be greater in loose and partially fluid material, than in clay or compact soil.

The use of the Nasmyth machine demonstrates the value of quick blows, not only in the economy of driving, but also in obtaining a deeper penetration, which is often very desirable.

The comparative cost of driving by the use of different kinds of power is nearly as follows:—

| | |
|---|---|
| By steam with the Nasmyth ram | 5· |
| " " ordinary machines | 9· |
| " horse-power with " " | 12· |
| " man-power—tread-wheel | 15· |
| " " cranks | 20· |

And these sums represent cents per lineal foot of pile driven in 1846.

In February, 1861, I made some experiments to determine the supporting power of large iron columns considered as piles—that is, of the external frictional resistance. I regret that the circumstances of the case did not warrant the extraordinary expenditure necessary to determine the absolute sustaining power of iron piles, but it is interesting to know, that the piles sustained a load of 716 pounds per square foot without any movement, at a time when the material around it had been for weeks disturbed and loosened by the constant escape of air from the pneumatic process, which was being carried on at another column but six feet distant.

I am of the opinion that this column would have sustained double this load before it would have moved; but for safety, I have assumed half a ton per superficial foot of the exterior frictional surface of iron piles, which is one-half as much as I ascertained that wooden piles would bear.

The frictional resistance depends upon the extent of the surface in actual contact, which in the minute particles of sand at the Navy Yard, must give the largest co-efficient. At Harlem the silting of the same kind of fine sand between the interstices of the gravel and stone, would also give a large co-efficient, but probably not as great as the former.

The angular particles of the sharp sand would probably be indented into wooden, but not into iron piles, and, together with the less regular surface of the former, would increase its frictional resistance. A careful consideration of these circumstances, as well as of the experiments, confirm the opinion above expressed.

I have recently seen a reference to the English practice, in which it is stated that the rule there, is to allow 600 pounds per square foot for this resistance on iron piles.

The allusion is no more definite than above stated, and does not specify whether this is the safe load or the ultimate strength, nor does it state to what kind of soil it refers. If these facts were known to us, one could determine whether it confirms or contradicts the results and opinions which I have above expressed.

It may be interesting to some of the profession present, to state how these experiments were conducted.

The main beam of the lever was a stick of Georgia pine, 60 feet long, averaging 18 by 16½ inches. The short arm was 4 feet long; the bearing points were turned steel rollers, 1½ inches diameter and 12 inches long, set in and bearing upon cast iron plates, also bored out. The lever was strongly trussed by a king-post of oak 9 feet high and 13 inches square, resting on a cast iron block, and arranged with folding wedges at the bottom, to strain the truss to its bearings. A heavy cast iron saddle was fitted to the top of the post, through which passed a large turned iron pin. The long truss rods were two bars of iron 2½ by ¾ inches, and the shorter rods of three pieces of 1⅞ inch iron, connected to a joggle by two links of iron, and by lugs of iron on a heavy plate on the main beam, and another heavy plate of iron was placed near the outer end of the main beam, to which the long truss rods were attached or hooked on lugs.

The truss was calculated to allow a strain of 150 tons to be placed upon the column, but was strong enough to have allowed twice that strain.

The leverage being 14 to 1, would have brought an uplift of 2000 tons on the fulcrum. The works were carried on in the middle of the river, from a temporary platform of piles, which would not have borne this load, and therefore we had to depend upon the combination of such load as the platform would bear, the resistance of its piles to an uplift, and a series of trusses, by means of all which the tenacity of nearly forty of the platform piles was obtained, and, in a later experiment, by using the weight and resistance of a large iron column already driven a short distance into the earth.

But the constant escape of the condensed air into the earth of the river-bed, had so loosened the hold of these platform piles, that they yielded when the uplift pressure reached seven hundred tons, and, to our deep regret, the experiment had to be discontinued, almost at the point when it would have fully demonstrated the problem so earnestly desired.

I am now desirous of calling the attention of the profession to the value of iron piles for foundations in deep water, and where the use of wooden piles is objectionable.

I commence by stating my opinion, that in difficult cases, these iron piles or columns may be substituted with economy for wooden ones, or any of the usual substitutes of coffer-dams and caissons; and with the knowledge we already have, the engineer can rest assured that with these columns his foundations can be rendered safe beyond question.

To illustrate my views, I propose to take for an example the case of our western rivers, where many bridges are now being proposed for railroad crossings, and where the like difficulties occur, as in crossing many of our Atlantic coast estuaries.

For more than twelve degrees of latitude, these western rivers, in nearly all cases, flow through valleys many times wider than the stream, and bounded on each side by high rocky bluffs, which are nearly parallel, and from one to five miles apart. These rivers always run alongside of one or the other of these bluffs; but, after following one side for five, ten, or fifteen miles, some obstruction turns them off towards the opposite bluff, which they follow until again deflected to the opposite side of the valley.

The railroad crossings must necessarily be made, where the river channel is against the bluff, on one side or the other.

The valleys between these bluffs have, at a remote day, been scoured out to a great depth, and are now filled with diluvium. The river channels have scoured out the bed next to the bluff, down to the rock, whenever it lies at less than twenty to thirty feet below low water; but as these rock slopes are steep, not more than one-third of the piers of a bridge can be founded on the rock at a reasonable depth, and for the remainder of the length of the bridge the rock is beyond reach, and the piers must be supported on the sand which has been silted into the deep chasm between the bluffs.

This material is generally silicious or mixed with calcareous matter, and some loamy earth, and never becomes a coarse sand.

The Mississippi River has a fall of from four to six inches per mile, and the Missouri of ten to sixteen inches, and the smaller navigable streams a fall between the extremes of these ranges. The currents of the former are from three to five miles an hour in low water, and reach a superficial velocity eight or ten miles in the great floods. The velocity of the Missouri is still greater.

During the floods, these rivers wear away the banks and scour out the bottom, carrying forward much solid matter in suspension, and as the floods begin to subside, this suspended matter is deposited wherever the force of the current is lessened. Thus, during freshets, the main channels are scoured out, and in some places deep holes made; as the water falls, many of these holes fill up, and so do the channels.

The river-bed is of so fine material, that this alternate scour and deposition is in constant action, and this is particularly noticeable where any obstruction is placed in the channel; a sunken vessel or a mass of flood-wood has sometimes, especially on the Missouri, changed the channel of the river for miles, scouring out holes forty feet or more in depth, or silting up islands in mid-channel.

The problem of founding piers for a bridge over such streams, is one of the most interesting to the profession. The only two bridges which now cross the Mississippi—the Rock Island and Clinton—are where there exists a chain of rocks entirely across the river; and these two places, with another at Des Moines, form the only exceptions to the description which I have above given of the general character of this stream.

The necessities of commerce, however, demand crossings at many other places than these exceptional ones, and it is the province of the engineer to meet these demands.

The careful engineer, before commencing the construction of such a bridge, will study the stream well, and ascertain the greatest depth of water which its freshet currents produce, not only at the site of the proposed bridge, but far up and down stream. He knows that no obstruction can be placed in a stream like that of a series of bridge-piers, for producing the greatest scour, and especially if an ice or drift-wood gorge should occur at his bridge, to which it is peculiarly liable, from the frequency of the obstructions, extending entirely across the channel.

Will wooden piles afford a safe foundation for such a structure?

The sand of the river-bed, although so easily removed by the water, strongly resists the penetration of piles when driven in the ordinary manner. The timber is not strong enough to resist the force of a blow, or rather, the resistance of a penetration of more than twenty-five feet, though perhaps the Nasmyth machine would obtain one of thirty feet. One-half of the piers would probably, and some of them would certainly, have to be founded on one of the bars in shallow water. If the water was in this case five feet deep at low water, and a scour of twenty-five feet only should take place, the piles would be washed out. If a pit should be dredged say to twenty feet below low water, and the pile be forced to penetrate thirty feet, and a scour of thirty feet should occur, the piles would have lost $\frac{5}{9}$ths* of their supporting power, and their number must be accordingly increased.

The expense of these additional piles, and of the curbing to keep the sand from filling the pit, and the extra cost of very long piles, would go far towards paying the cost of iron piles.

When the pit was dredged, as above stated, to give piles a penetration of thirty feet, it would require very long timbers, viz: to reach not only up to the level of low water, but five or ten feet above it, to allow the operation of driving them to be carried on, at such times as the case demands, which would rarely be in seasons of dead low water.

The vibrations of such long timbers would absorb some of the force of the blows, and it is very doubtful whether even Nasmyth could drive them to a penetration of thirty feet.

It would then appear that the limit of the use of wooden piles for the foundations of piers under the assumed circumstances, is when the scour of the river will not reach to a depth of thirty feet below low water.

But it is well known that holes have often been scoured out to a depth of forty feet, and on the Missouri to a still greater depth; and in all such places, foundations of that sort would be wholly destroyed, and with them the valuable superstructures.

It has been said that the piers can be protected by masses of riprap around their base.

The use of such protection has often been tested, and in certain places is valuable. For the case in question it is valueless. Its effect would only be to produce a deeper scour at its outer extremities, into which it would tumble stone by stone, leaving the bed of the river nearer and nearer to the pier, exposed to the same scour, until finally the piles would be undermined, as if no such protection had been used.

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* $20 + 30 = 50$ to the bottom of the pile. Deduct the scour of 30, and it leaves the pile but 20 feet into the earth. Its supporting power is then reduced to $\frac{20^2}{30^2}$, or a loss of $\frac{5}{9}$ths.

The worst scouring will occur in the high freshets, and its operation, concealed from view, will only be developed when the pier begins to totter, and such a supposed protection is only a delusion, which, if it is really relied on, may prove the cause of the destruction of the bridge.

But I turn from this subject, on which perhaps I have dwelt too long, to the substitution plans to which I desire now to call your attention, viz: the use of iron piles for foundations, or of large iron columns, which will not only form the piers themselves, but also their own foundations.

(To be continued.)

# DEEPENING OF THE MICHIGAN AND ILLINOIS CANAL.

By S. W. Robinson, C.E.

The valley of the Des Plaines River, in the State of Illinois, is supposed to have been at some period during the geological ages, the course of a river which formed an outlet to the Great Lakes, and a tributary to the Mississippi.

The bed of this valley, at present, scarcely rises twenty-five feet above the level of Lake Michigan, the summit being only ten or fifteen miles from the lake.

The Michigan and Illinois Canal, which extends down this valley, is 96 miles in length, and joins Lake Michigan, at Chicago, with the Illinois River at La Salle. This canal was commenced about thirty years ago. It has now been in use for several years, the boats being carried over the summit by the use of locks, situated at Chicago and near Lockport, which retain the water upon a level ten feet higher than the Chicago river and Lake Michigan.

Since the city of Chicago has suffered in such a marked degree from the notable stench of the Chicago River, it has been determined to deepen this canal across the summit, so as to induce a current of water down the valley into the Illinois River. This will form an artificial river, by which water will be carried from the lakes towards the Gulf of Mexico. Although the amount of water carried to the sea by this course will be small, yet the fact will exist of two outlets to divide the waters of the great lakes, and depreciate the honors of the St. Lawrence.

The amount of deepening required to effect this, is about ten feet between the locks above named, for a distance of 27 miles. The working depth of the canal is to be six feet, reckoned from the low water mark of Lake Michigan; the breadth of the canal at the bottom is to be 50 feet, and, six feet from the bottom, 60 feet.

This work of deepening was commenced two years ago; and will probably be finished by the middle of April, 1869. That navigation shall not be interfered with, the work is done between the middle of the months of November and April, each winter. The deepening requires the removal from the bottom of the canal of about two and a half million yards of earth, and two hundred and forty thousand yards of solid rock.

The former is contracted variously at from half a dollar to a dollar per yard, and the latter at from 2⅛ to 2¼ dollars per yard.

The city is permitted by the State to prosecute this work to the extent of two and a half million dollars, with the understanding that it shall be reimbursed by revenues from the canal, if not sooner paid directly by the State, which, the writer has been informed, will be done, if the State widens the canal to 80 or 100 feet to accomodate the Mississippi flat-boats. The excavation is earth for a distance of 20 miles from Chicago, where the excavation of magnesium lime-rock commences, which extends about seven miles further, reaching nearly to Lockport.

This part of the canal runs through the limestone beds from which the excellent building stone for the city of Chicago is quarried.

To loosen the rock in the canal, blast-holes are used which are 4 to 6 inches in diameter and 6 to 10 feet deep. These have heretofore been bored by raising the drills by horse or steam-power, then letting them drop, gravity doing the work of striking the blow.

The drills principally used for this purpose are about 20 feet in length and 2½ or 3 inches in diameter, and of iron, except at the cutting end, which is enlarged with steel to nearly the size of the hole for one or two feet, and armed with a Z-bit.

Experiments are now being made with direct-action steam drilling machines at the works of Messrs. Singer & Talcott.

Much difficulty has been experienced in effecting the speedy removal of the chips which are formed so much faster than by other appliances heretofore used for drilling. This difficulty, however, is likely to be overcome; and the time is probably near at hand when direct-action steam-drills will be used on all our great works in rock excavation throughout the country.

The rock is raised from the bottom of the canal to the banks, by means of cranes or derricks, worked by horse-power.

The cranes have the advantage of being portable, being mounted upon movable platforms. The derricks, however, perform the operation of hoisting more satisfactorily, and require less work than the cranes, as there constructed.

The easiest working derricks used there are those in which the boom would swing entirely around the mast in disposing of each load. They were so constructed that the horse or horses traveled around the mast, and in the same direction as the boom. The mast rests upon the centre of the sweep to which the horse is attached, and the friction between the mast and sweep, induced by the movement of the latter, causes the boom to move and carry the load around simultaneously with being raised, from the pit to the bank, ready to be dumped. One of the smoothest working derricks I saw, had a friction clutch for communicating power to the cable, the latter being of steel wire instead of a chain.

One horse worked this with apparently as much ease as two could the cranes, having a chain cable, and where the cranes required two to four men each, beside the driver, to manage them, the derricks required but one. These derricks were invented by A. T. Merriman & Brother of Chicago.

University of Michigan, January 20th, 1868.

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## WOOD HANGINGS FOR WALLS.

We have received from New York some samples of a new article of manufacture, which is intended to supersede the process of papering walls. It is to cover the walls with wood itself, and this at a less expense than covering by paper. The wood is cut into rolls so thin that a log, measuring twenty-four inches in diameter, would make one hundred and twenty-five rolls, containing thirty-six square feet each. One machine will shave two square rolls per minute, or one thousand rolls per day. We may now have our walls "hung," to match our furniture, with real walnut, mahogany, birch, rosewood, maple, poplar, or any other variety desired.

This "wood hanging" is merely a very thin veneering, and may be placed on the walls by paper-hangers in the ordinary manner.

A company has just been formed for the manufacture of this material in New York.

# Mechanics, Physics and Chemistry.

## LECTURE-NOTES ON PHYSICS.

By Prof. Alfred M. Mayer, Ph D.

(Continued from page 44.)

### 2. *Instruments used in the Measurement of Angles.*

Note.—On page 325, vol. liv., eight line from foot, for "*to* what is called the inductive," substitute "*by* what," &c.

The circumference of the circle is divided into 360 parts, one of which is called *a degree*—the unit of angle measures. The degree is divided into 60 *minutes*; the minutes into 60 *seconds*; the subdivisions of the second are decimal. The sign of the degree is (°); of the minute (′); of the second (″).

*Theodolite*, *Meridian Circle*, *Sextant*, *&c.*, described from the instruments, and from diagrams.

*The Micrometer* consists of two spider-lines, stretched parallel to each other, on two frames, each moved by a micrometer screw, so that the threads can be made to approach to, or recede from, each other. The spider-lines are exactly in the focus of the object glass of an achromatic telescope, so that the image of any object formed by the object-glass, and the lines, are in the same plane, and therefore both equally distinct, when viewed through the ocular of the telescope. The value of one turn of the micrometer screw may be estimated in angle units, by causing the spider-lines to embrace the vertical diameter of the sun, when it is on or near the meridian; and then, by obtaining its exact diameter from the Nautical Almanac, we can, after allowance made on our measure for refraction, reduce a turn of the screw to its value in angle.

The invention of the micrometer is due to William Gascoigne, who also first applied the telescope (invented in 1609, by Galileo) to a graduated circle. Gascoigne was killed, at an early age, while fighting for Charles I., at Marston-Moor, 2d July, 1644.

*The Reading Microscope* is a similar contrivance to the Micrometer; the difference being, that the micrometer spider-lines, which cross (×) each other, and are moved by one screw, are placed in the focus of a microscope, instead of in the focus of a telescope. The Reading Microscope is placed over the divisions of a graduated circle, and is so adjusted that five turns of the screw will carry the point of bisection of the cross (×) lines, the length of the smallest division on the circle, which generally equals 5′ of arc. The head of the screw of the reading microscope is divided into 60 parts, so that when the screw is revolved through one of these parts, the cross (×) lines are carried over the circle, a distance equal to *one second* of arc. In those circles used in the most accurate determinations of astronomy, the microscopes read to $\frac{1}{10}$ of a second of arc; and this minute accuracy is absolutely required in many problems now in process of solution by Astronomers—(*e. g.* the parallax of the fixed stars).

The difficulty of measuring with accuracy to a fraction of a second, will be readily appreciated, when we know that one second of arc occupies, on a circle of 6 feet in diameter, a length of only ·0001745 of an inch.

For an excellent method of stretching spider-lines in the micrometer, devised by Lieut. M. F. Maury, see Washington Astronomical Observations, 1845.

*Reflecting Goniometer.* Used in the measurement of the angles of crystals. Invented by Dr. Wollaston, in 1809. "This instrument will give the inclination of planes of crystals, whose area is less than $\frac{1}{100000}$th part of an inch, to less than one minute of a degree." (Ency. Metrop. Art. Crystallography.)

Instruments exhibited, and method of using explained, by measuring the angle of a crystal.

*The Spirit Level* is formed of a *slightly* curved glass tube, nearly filled with ether. A bubble of air occupies the highest portion of the convex side of the tube.

Spirit levels have been made of such extreme delicacy, that an inclination of one second of arc, in the plane on which the level rests, would cause the bubble to move three millimêtres; the curvature of the tube of the level, in this case, was 619 mêtres. M. Biot used, in his measurement of the arc of the meridian passing through Dunkirk to Formentera, a level whose bubble moved one millimêtre for an inclination of 1″·79.

By the aid of the levels of the best mechanicians we can safely estimate *tenths of seconds* of arc.

The level appears to have been known to the ancient astronomers of India.

### 3. *Instruments used in the Measurements of Volumes.*

Volumes of liquids and of gases are measured in graduated cylindrical tubes.

A tube or vessel of any form may be graduated into cubic centimêtres, by marking the levels reached by successive equal portions of mercury poured into the tube or vessel; each portion being equal to the exact weight of one cubic centimêtre of mercury, of the temperature at which the mercury is when the weighing is performed. It is better, however, first to divide the tube into equal divisions of length, say millimêtres, on a dividing engine, and then, with a short tube, whose aperture is closed with a ground glass plate, and whose capacity is exactly one cubic centimêtre, to measure off and pour into the tube, cubic centimêtres of mercury. After each addition, the number of millimêtres to which the mercury rises is noted in a table, and thus the value in capacity of each division of the tube is deduced.

For further information on this subject, see Bunsen's *Gasometry*, London, 1857; and the papers of Regnault, published in the Transactions of the Institute of France.

*Volumes of solids*, as well as of liquids, may be determined by the estimation of their weight, at a known temperature, and under a known atmospheric pressure. In this method we have also to know the weight of a cubic inch, or of a cubic centimêtre of the solid or liquid. The advantage of the French gramme weight is shown in this determination of volumes, by weight; for the *specific gravity* of a body is equal to the weight of one cubic centimêtre of the substance, in grammes; for one cubic centimêtre of water, at 4° C., weighs one gramme.

### 4. *Instruments used to Measure Weights.*

Two units of weight are used in this country: *the grain*, fixed by the weight of one cubic inch of distilled water, at 62° F. and 30 inches of the barometer, one of such cubic inches of water weighing 252·456 grains. The other is the French unit, the gramme, which is derived from the weight of one cubic centimêtre of distilled water, at 4° C.

*The Balance.* Saxton's U. S. Standard Balance exhibited and described. Becker's Analytical Chemists' Balance. This balance will weigh to the $\frac{1}{10}$th of a milligramme, with each pan carrying a weight of 50 grammes; or, in other words, its beam will turn with $\frac{1}{500000}$th of that weight, the index being deflected $\frac{1}{3}$d of a division of the scale from the position of equilibrium.

See a paper by W. Crookes, in the *Chemical News* for 19th April, 1867, on the Correct Adjustment of Chemical Weights; and the investigations of Prof. W. H. Miller, of Cambridge, in the *Philosophical Transactions* for 1856.

*Method of Double Weighing.* Invented by Borda of Paris. Consists in counterpoising a mass, whose weight we desire, by shot, sand, thin copper foil, or pieces of fine wire, and then replacing the mass by weights, until equilibrium is again established. The weights are thus placed in exactly the same conditions as the mass, and therefore this process eliminates all errors arising from unequal length of the arms of the balance, etc. This process is far more accurate than single weighing.

*The weights of very small portions of matter*, such, for example, as *chemical traces*, can be estimated by the deflection of a very fine filament of glass, one end of which is cemented to the edge of a block, and the other end has hanging to it, a still finer filament, supporting a disk, about $\frac{1}{2000}$th inch thick, made of elder pith, on which is placed the substance, whose weight we determine by the amount of deflection it causes in the glass filament. With this apparatus can be estimated the deflection produced by the $\frac{1}{1000}$th of a millimêtre.

See a paper by the author in Silliman's *Journal of Science*, vol. xxv., page 39, 1858, describing this instrument.

### 5. *Instruments used in the Measurement of Time.*

Definition of time, from Laplace's Système du Monde, ch. III:—"Time is for us the impression which is left in the memory by a series of events, whose existence we are certain has been successive. Motion can serve to measure it; for a body not being able to be in several places at the same time, can only go from one point to another, by passing successively through all the intermediate points. If at each point of the line which it describes, it is animated with the same force, its motion is uniform, and the parts of that line can measure the time employed to run over them. When a pendulum at the end of each oscillation is found in exactly the same circumstances, the durations of the oscillations are the same, and time can be measured by their number. We can also employ for that measure, the revolutions of the celestial sphere, which are always equal in duration; but all have unanimously agreed to use for that object the motion of the sun, whose returns to the meridian, and to the same equinox, or to the same solstice, form the days and the years."

The duration of one revolution of the celestial sphere constitutes a sidereal day; while the time of one mean revolution of the sun equals a mean solar day. The sidereal day, which is used by astronomers, is 3m. 55·5s. less than the solar day.

Both days are divided into 24 hours; each hour into 60 minutes; and each minute into 60 seconds; the seconds are sub-divided decimally. The hours are designated by the sign *h*; the minutes by *m*; the seconds by *s*. Both days are divided into 86,400 seconds.

The real unit of time must be the *sidereal day*, being the duration of one revolution of the earth on its axis. From recorded ancient eclipses, it has been computed that the time of this revolution has not altered by $\frac{1}{10000000}$th of its length, from B. C., 720. From the sidereal day is readily deduced the value of the mean solar day.

*The Astronomical Clock* A clock consists of a train of wheel-work (moved by the descent of a weight) which maintains and indicates the vibrations of a seconds pendulum. The Astronomical clock is made with every refinement of workmanship; it has generally a "*dead-beat*" escapement, and has always a pendulum, which is so compensated that a change of temperature does not alter the length from the point of suspension to the centre of oscillation of the pendulum.

*The Chronometer* is a large watch, very accurately constructed, having a "*chronometer escapement*" and a carefully compensated balance-wheel. It beats half-seconds.

It is not required that a clock or chronometer should keep the exact time, but it *is* required that the daily *rate* of *variation* from the true time should be constant.

The pendulum clock was invented by Huyghens, of Holland, in 1658; and in the same year Hooke of England applied the spring-balance to time-keepers.

*Seconds Stop-Watch* exhibited and described.

*A uniformly revolving cylinder* was first proposed by Dr. Thomas Young, for the measurement of intervals of time. With this apparatus we can, in certain cases, measure the $\frac{1}{10000}$th of a second. "By means of this instrument, we may measure without difficulty the frequency of the vibrations of sounding bodies, by connecting with them a point, which will describe an undulated path on the revolving cylinder. These vibrations may also serve, in a very simple manner, for the measurement of the minutest intervals of time; for if a body, of which the vibrations are of a certain degree of frequency, be caused to vibrate during the revolution of an axis, and to mark its vibrations on a roller, the traces will serve as a correct index of the time occupied by any part of a revolution; and the motion of any other body may be very accurately compared with the number of alternations marked in the same time, by the vibrating body." From Dr. Young's *Lectures on Natural Philosophy and the Mechanical Arts* (a work to be thoroughly studied by all students of physics), 2d Edit., London, 1845, page 147. See, also, an article on "Apparatus and Experiments," devised by the author, in the Franklin Institute Journal, for November, 1867.

The revolving cylinder has recently been applied to the registration of transit observations. The apparatus described, with diagrams.

*Kater's Method* of determining small intervals of time, by weighing the mercury which flows from a small orifice, under a constant pressure.

*Revolving Mirror.* Invented by Prof. J. Wheatstone, of London, who, in 1834, measured with it the velocity of electricity. Improved by Arago, and proposed by him to the Institute of France, in December, 1838, to determine the velocity of light. In 1850, Foucault of Paris, so perfected its construction and arrangement, that he measured with it, accurately, the $\frac{1}{15000000}$th of one second of time.

The principle of the apparatus can be rendered clear in a few words. Suppose a ray of light, entering a dark room by a fine slit, falls upon a rapidly revolving mirror. This ray is reflected from the *revolving* mirror to a *fixed mirror*, distant from it say 20 feet. The ray reflected from the fixed mirror, falls again upon the revolving mirror. Now, suppose that in the time the light takes to go from the revolving mirror to the fixed mirror, and to return to the revolving mirror, that by its rotation, the face of the revolving mirror changes its position: then this causes a deviation in the ray reflected on its return to the revolving mirror, compared with its direction when it left the revolving mirror to go to the fixed mirror. Therefore, knowing the time it takes for the mirror to make one revolution, we can compute, from the deviation produced, the time required by the light to go over double the distance from the revolving mirror to the fixed mirror. This distance, in Foucault's experiment of 1850, was only 4 metres (13·12 feet); and the mirror, making 800 turns in a second, produced a deviation in the return ray of $\frac{3}{10}$ millimêtre.

In 1862 Foucault repeated his measurements with a far more precise instrument, and increased the distance of the mirrors from 4 to

20 metres (65 feet 7·4 inches). The result of his measures gives a velocity of light equal to 185,177 miles per second, differing slightly from the measure obtained by astronomic observations, when we use for this reduction the solar parallax, with the increase in amount which it appears from recent observation we should adopt.

The most important result obtained with this apparatus, was the fact that light moves slower in water than in air, the velocities into two media being as 3 is to 4. In short, the index of refraction expresses the ratio existing between the velocities of light in the two media.

"An admirable experiment in physics, in which, by the power of intellect and manual skill, we have succeeded not only in rendering sensible, but even measurable, the time employed by light to run over a path of 20 metres, although this time barely equals the $\frac{1}{15000000}$th of a second! and which, if we repeat so as to vary its elements, and thus make evident the constant causes of error which affect the result, appears capable of giving a determination of the velocity of light altogether as precise as that which is deduced from astronomical phenomena!" For further information of this method, see "Essay on the Velocity of Light," by M. Delaunay of the Institute of France; translated for the Smithsonian Institution by Prof. Alfred M. Mayer, 1864.

*Calculating Engines.* The great importance of such machines in giving us *faultless* logarithmic, astronomical, nautical, and other tables. Impossible to calculate and print any extensive table without making errors.

For a description of the Arithmetical Machine of Pascal, see *Oevres de Pascal*, vol. ii., page 368, et. seq. Hachette, Paris, 1860.

For information in reference to Charles Babbage's celebrated engines, see *Edinburgh Review*, 1834; Taylor's *Scientific Memoirs*, vol. iii., 1843, London, in which is a description by General Menabrea, of Babbage's Difference Engine, and of his more recent and far superior Analytical Engine, translated, with extensive notes, by the accomplished Lady Lovelace, the only daughter of Lord Byron.

See also Passages from the Life of a Philosopher, by Charles Babbage, London, 1867.

Exhibit the "Tables calculated, stereomoulded, and printed by machinery," London, Longmans & Co., 1857. The engine by which these tables were calculated was made by George and Edward Scheutz, of Stockholm, and is now the property of the Dudley Observatory, at Albany, N. Y.

## TABLES FOR THE COMPARISON OF THE FRENCH AND ENGLISH SYSTEMS OF MEASURES AND WEIGHTS.

### *Measures of Length.*

| Denomination and Value. | | Equivalent in English Standard. |
|---|---|---|
| Myriametre | 10,000 metres | 6·2137 miles. |
| Kilometre | 1,000 " | 0·62137 mile = 3,280 feet 10 inches. |
| Hectometre | 100 " | 328 feet 1 inch. |
| Decametre | 10 " | 393·707 inches. |
| METRE | 1 metre | 39·37079 " |
| Decimetre | $\frac{1}{10}$ " | 3·937 " |
| Centimetre | $\frac{1}{100}$ " | 0·3937 " |
| Millimetre | $\frac{1}{1000}$ " | ·03937 " |

### *Measures of Surface.*

| Denomination and Value. | | | Equivalent in English Measure. | |
|---|---|---|---|---|
| Hectare | 10,000 square metres | | 2·471 | acres. |
| ARE | 100 " | " | 119·6 | square yards. |
| Centare | 1 " | metre | 1,550 | " inches. |

### *Measures of Capacity.*

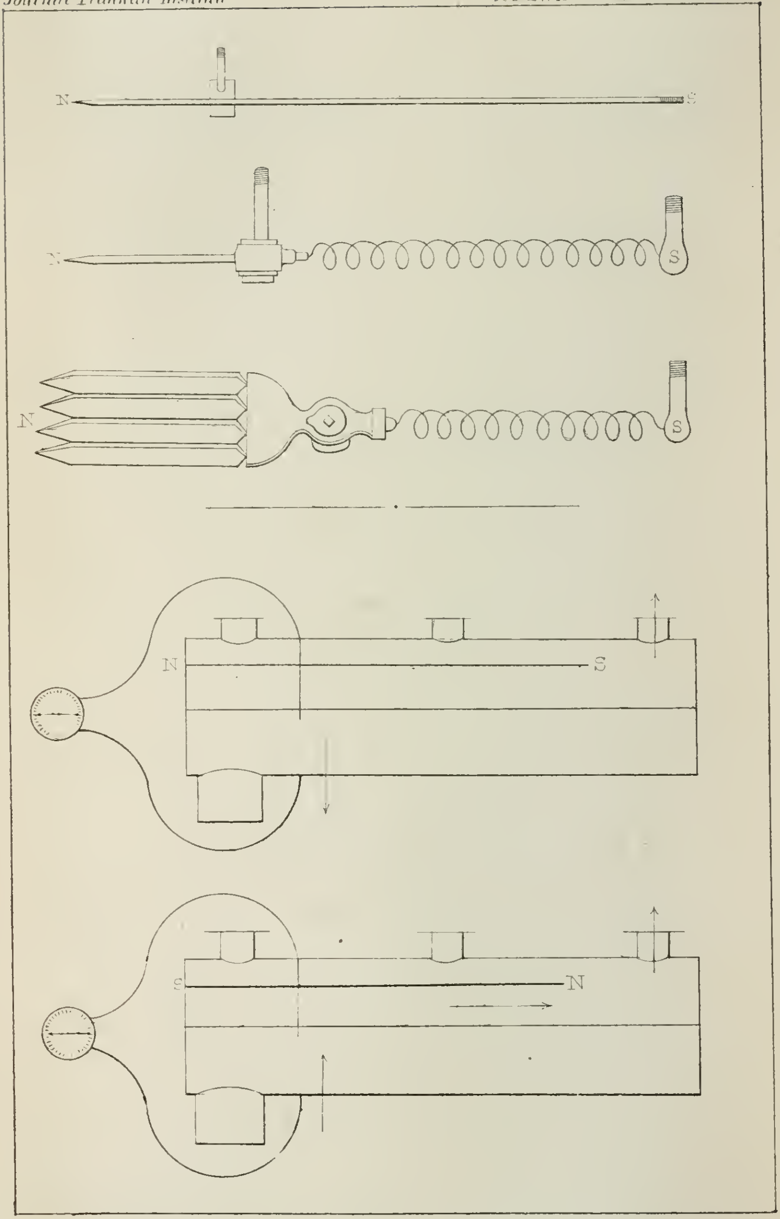
| Denomination and Value. | | Equivalent in English (Wine) Measure. | |
|---|---|---|---|
| Kilolitre or Stere | 1000 litres | = 1 cubic metre | 264·17 gallons. |
| Hectolitre | 100 " | = $\frac{1}{10}$ " " | 26·417 " |
| Decalitre | 10 " | = 10 " decimetres | 2·6417 " |
| LITRE | 1 litre | = 1 cubic decimetre | 1·0567 quart. |
| Decilitre | $\frac{1}{10}$ " | = $\frac{1}{10}$ " " | 0·845 gill. |
| Centilitre | $\frac{1}{100}$ " | = 10 cub. centim. | 0·338 fluid oz. |
| Millilitre | $\frac{1}{1000}$ " | = 1 " " | 0·27 " drm. |

### *Weights.*

| Denomination and Value. | | Equivalents in English Avd. Weight. | |
|---|---|---|---|
| Millier or tonneau | = 1,000,000 grms. | = 1 cub. met. of W. @ 4° C. | = 2204·6 lbs. |
| Quintal | = 100,000 " | = 1 hectolitre " " " | = 220·46 " |
| Myriagramme | = 10,000 " | = 10 litres " " " " | = 22·046 " |
| Kilogramme or kilo | = 1000 " | = 1 litre " " " " | = 2·2046 " |
| Hectogramme | = 100 " | = 1 decilitre " " " | = 3·5274 oz. |
| Decagramme | = 10 " | = 10 cubic centim. " " | = 0·3527 " |
| GRAMME | = 1 " | = 1 " " " " | = 15·43235 gs |
| Decigramme | = $\frac{1}{10}$ " | = $\frac{1}{10}$ " " " " | = 0·5432 " |
| Centigramme | = $\frac{1}{100}$ " | = 10 cub. millim. " " | = 0·1543 " |
| Milligramme | = $\frac{1}{1000}$ " | = 1 " " " " | = 0·0154 " |

Inch = 25·39954 millimetres.
Foot = 3·047945 decimetres.
Mile = 1609·315 metres.
Square Inch = 6·451367 square centimetres.
" Foot = 9·28997 " decimetres.
" Yard = 83·60971 " "
" Acre = ·4046711 of a hectare.
" Mile = 258·9895 hectares.
Cubic Inch = 16·38618 cubic centimetres.
" Foot = 28·315312 " decimetres, or litres.
Gallon = 4·54346 litres.
" = 277·274 cubic inches.
Grain = 64·79896 milligrammes.
Pound Avd. = 453·5927 grammes.

(To be continued.)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# RESULTS OF EXPERIMENTAL TRIALS OF THE AMERICAN ANTI-INCRUSTATOR.

By Charles M. Cresson, M.D.

[The subject of the American Anti-Incrustation is one of curious interest, as well as great practical importance. At its first appearance it had the unfortunate aspect of an absurdity or a humbug, having been linked to an explanation or theory, embodying most of the popular errors and confusions respecting the nature of electricity, which are current among the ignorant. Multiplied facts demonstrating practical efficiency, independent of theory, however, at last lead gentlemen of education and established scientific reputation, to take the matter in hand, and give it the support of their names and authority as witnesses of fact. Testimony of the strongest kind from many sources has thus been accumulated, as to the fact that, in a vast number of cases, the instrument *does* produce the effects claimed for it.

To the purely practical mind this may be sufficient, but to the generality of mankind a sensible want would be supplied, if a reasonable solution could be furnished to the natural question, How are these results produced? It is, therefore, with pleasure that we present to our readers the following communication, prepared by Dr. Charles M. Cresson, in response to a letter from James Harper, Esq., Managing Director American Anti-Incrustation Co., which we believe to be the first essay, of a thorough and scientific character, which has been made towards the solution of this new and curious problem.—Ed.]

Office and Laboratory,
Schuylkill Navigation Building, 417 Walnut St.,
*Philadelphia, April 15th,* 1867.

James Harper, Esq.,
*Managing Director American Anti-Incrustation Co.*

Dear Sir:—In answer to yours of the 9th inst., I have prepared this condensed statement of the most prominent results of my examination of your instruments for the removal and prevention of scale in steam-boilers, with the deductions which seem to follow from the experiments.

In order to make the explanations of the principles involved more intelligible, I have prepared a few simple diagrams, exhibiting to the eye the direction of the obscure currents produced by the conjunction of electrical and magnetic forces.

The apparatus furnished by the American Anti-Incrustation Company consists, in its simplest form, of a magnetic bar of hardened steel, suspended horizontally within the steam-boiler, in the upper part of the steam-space, the south pole of the bar connected with the shell of the boiler, and the north pole supported by an insulated hook.

If the magnetic bar be not of sufficient length to extend nearly throughout the horizontal steam-space, it may be prolonged by a rod or wire of metal, so as to connect the south pole with the boiler, care being taken to keep this wire insulated from immersion in the water, and from metallic contact with the boiler, except at its point of attachment to the shell.

In large boilers it is usual to place three or more bar-magnets side by side, with their south poles, secured to a block of metal, which block is connected with the shell of the boiler; and in very long boilers several instruments may be set at varying distances from the end of the boiler, all presenting the south pole to that end with which they are connected.

Experimental trials made upon the apparatus, and modifications of it, have elicited certain facts.

If we replace the magnet-bar by a bar of steel, without polarity, and employ a solution in the boiler which will deposit scale upon the application of heat, we find that the neutral bar gradually obtains polarity, and that the insulated end becomes a south pole; the deposit of scale then taking place with great rapidity.

With the magnet-bar properly placed, with its north pole insulated and its south pole connected with the boiler, the scale already formed is gradually removed, and any fresh deposit prevented.

During the performance of this work, the bar slowly loses its polarity, and if, at this time, it be not remagnetized, it will eventually assume the reverse polarity, and fail to prevent the formation of scale.

If, in placing the instrument within the boiler, we so arrange it that the outflowing steam shall pass along the bar in the direction from its south pole towards its north pole, then is its action increased; but if the outflowing steam pass it in a contrary direction, we may not only retard, but entirely prevent, the proper working of the instrument.

In order to determine the effect of the polarized bar upon the electrical currents in the water, insulated wires were passed through the outer shell of the boiler, and the exposed ends of the wires fixed at varying distances from the bottom surface inside. These wires were successively connected with one pole of a galvanometer, whilst to the other pole was connected a wire in metallic contact with the shell on the outside.

During the formation of scale, the electrical current was mostly passing from the water to the shell. Upon inserting the polarized bar in a proper position, the direction of this current was reversed and passed from the shell to the water.

In addition to the influence of the nearly constant passage of steam from the boiler, by the ordinary outlet, various temporary minor modifications of the thermo-electric currents are caused by the use of the blow-out and gauge-cocks, and by any check to the fires beneath the boilers—such as by the addition of fresh fuel. The general direction of the current is toward an outlet of the boiler; more especially such an one as may be conveying off water or wet steam.

The tendency of electrical and thermal currents to proceed in the same direction, renders it a matter of some importance to locate properly the general steam outlet and blow-outs, in reference to the furnace, so that the currents induced may not interfere with each other.

To assist in explaining the relations which heat, electricity, and magnetism bear to each other, and the modes of their conversion, I have selected the following principles, as announced by Faraday, Grove, Noad, and others, in their researches, together with the illustrations of their action :—

"To obtain electricity from magnetism, it is necessary to superadd motion."

"Magnetism will produce electricity with the help of a dynamic force (heat)."

"Bodies affected by an electrical current, are definitely moved by a magnet in proximity to them ; and so, conversely, bodies moved near a magnet, have an electrical current developed in them."

Faraday's illustration of these abstract principles is as follows :—

"A copper plate, mounted on an axis, is furnished with a handle for giving it motion ; one wire, connected with a galvanometer, is retained in perfect metallic connection with the axis, and another, connected also to the galvanometer, is kept in contact with the circumference of the disk. A horse-shoe magnet is so placed as to embrace, with its poles, the disk and wire in contact with the circumference, but without touching them; the north pole of the magnet being towards the observer, and upon the left-hand side of the disk.

"When the machine is made to revolve from right to left, a current of electricity flows from the centre to the circumference of the disk. If the revolution of the disk, or poles of the magnet, be reversed, the direction of the electrical current is reversed also, and proceeds from the circumference to the centre of the disk. A similar effect can be produced by drawing a slip of metal between the poles of the magnet.

"So, also, when a plate of metal is made to rotate beneath a magnetic pole (suppose a north pole), a series of currents of electricity will pass from the centre to the circumference of the plate, if it is rotating in the direction of the hands of a watch; or, from the circumference to the centre, if it is rotating in the contrary direction."

This directive power, which the magnet possesses over electrical and thermal currents, explains why the magnetic force of the instrument, employed for removing incrustation from steam-boilers, should be diminished, and finally reversed, when the outflowing steam is compelled to pass it in a direction from its north pole to its south pole, and why the effect of the magnets is increased by the passage of steam in the contrary direction, or from its south pole to its north pole, as well as the occasion of the magnetic condition of the boilers of opposite polarity to that of the directing magnet, as the currents inducing it proceed from its upper surface.

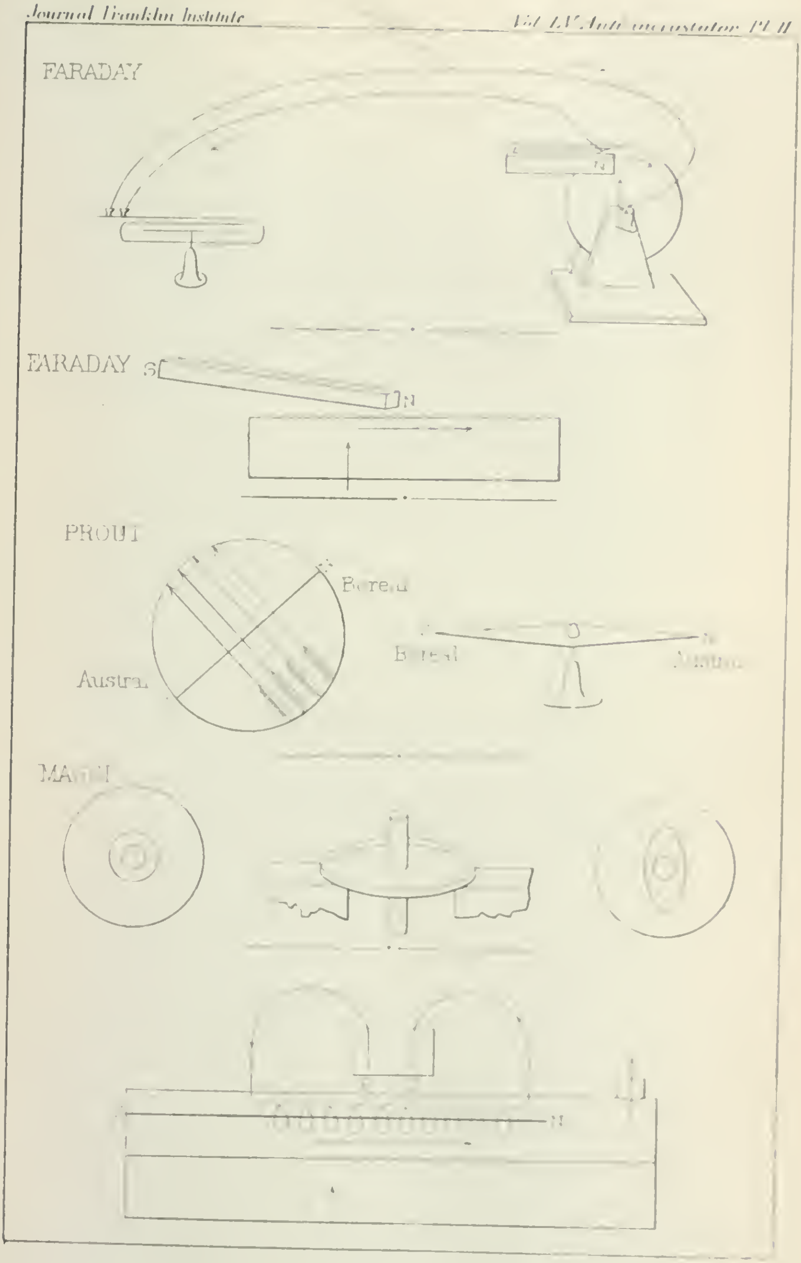
"An electric current appears to have a magnetic action in a direction cutting it at right-angles."

"Thermo-electricity connects heat with electricity, and consequently with magnetism."

To give an idea of the magnetic force, and its magnitude and direction, as developed by the action of apparently weak thermal currents, attention need only be directed to the earth itself. The earth is considered to be a great magnet, produced by electrical currents circulating around it.

Dr. Prout thus explains the causes of these electrical currents:—

"The earth, during its diurnal motion on its axis from west to east, has its surface successively exposed to the solar rays in an opposite direction, or from east to west. The surface of the earth, therefore, particularly between the tropics and in parallel zones, will be heated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and cooled in succession from east to west, and currents of electricity, on thermo-electric principles, will, at the same time, be established in the same direction. Now, these currents thus established, from east to west, give rise to the magnetism of the earth from north to south; hence the magnetic directive power of the earth, in a direction nearly parallel with its axis, is derivable from the thermo-electric currents, induced principally by its diurnal motion.

"When substances are undergoing chemical changes, and a magnet is brought near to them, the direction or lines of action of the chemical force will be changed. In these cases there is not a *production* of light, heat, or chemical affinity by magnetism, but a *change* in their *direction* or mode of action."

In illustration of this principle, Prof. Groves gives Dr. Maggi's experiment, exhibiting a change in the direction of thermal conduction under the influence of magnetic polarity:—

Cover a plate of homogeneous soft iron with a thin coating of wax, mixed with oil—a tube traversing the centre, through which the vapor of boiling water is passed, the plate to rest on the poles of an electro-magnet, with card interposed. When the iron is not magnetized, the melted wax assumes a circular form, the tube occupying the centre; but when the electro-magnet is put in action, the curve, marking the boundary of the melted substance, changes its form and becomes elongated in a direction transverse to the line joining the poles, showing that the conducting power of the iron for heat is changed by the magnetism.

From an examination of the principles above expressed and illustrated, in combination with other well-known laws, the following conclusions are reached:—

*First.*—In a steam-boiler, the thermal, and consequently the electrical currents, flow alternately towards and from the heated shell, as induced by variations of the temperature of the different parts of the shell and water, until some great disturbance of electrical tension is made by taking off steam or water rapidly; when, in order to restore the equilibrium of tension, electrical currents near to the shell of the boiler flow constantly to it—as the metal is a better conductor of electricity than water—carrying with them any matter that may be in solution or in suspension, and thus cause formation of scale in compact columnar form.

*Second.*—The thermo-electrical currents can be controlled by a suitable magnetic force; and therefore the magnets used in the

American Anti-Incrustation Company direct the lines of thermo-electric action, and in this way remove or enfeeble the causes of the compact deposition of bodies in solution or suspension in the water in the boiler.

*Third.*—Where scale has already been formed previous to the application of the instrument, it is repelled by the agency of magnetic and dia-magnetic forces, exerted in consequence of the polarity of the shell of the boiler, induced by the movement of the thermo-electric currents, directed or governed by the magnetic bar of the instrument; which repulsion favors the intrusion of a minute film of water between the iron of the boiler and the scale, and the latter is loosened and broken up by the expansion of the watery film into steam.

A further proof of the correctness of these assumptions, is found in the fact that, by exalting the intensity of magnetic action, by the substitution of a powerful electro-magnet in place of the weaker permanent magnets commonly used, the effects of deposition and removal of scale, as already described, take place with such increased rapidity as to produce, in a few hours, results which, with the ordinary apparatus, have required many weeks or months.

The introduction of metals in the water of the boiler, which are electro-negative or electro-positive to the metal in the shell (copper or zinc), either tend to corrode the boiler, or to oppose the action of the instruments.

In the whole course of these experiments there has been no evidence of the production of any galvanic action having the slightest tendency to oxidize, or in any way to injure the metal of the boiler.

Respectfully,

Charles M. Cresson.

## FLAME REACTIONS.

By Prof. Bunsen.

Translated by Prof. Charles F. Himes, Ph.D., Dickinson College, Carlisle, Pa

(Continued from page 54.)

The following are the incrustations that can be produced:—

*a. Metallic incrustations* are obtained by placing a particle of the specimen on an asbestus fibre, in the upper not too large reducing flame, with one hand, whilst with the other hand a very thin externally glazed porcelain capsule, 1 to 1·2 decimetres in diameter, filled with cold water, is held immediately over the asbestus fibre, in the upper reducing flame. The metals separate as coal black, dull, or shining incrustations and coatings. Even lead, tin, cadmium, and zinc give, reduced in this way, metallic coatings, which cannot be distinguished, by their appearance simply, from the blackening produced on porcelain by carbon. These incrustations, when treated, by the aid of a glass rod, with drops of dilute nitric acid, containing about twenty per cent. of anhydrous acid, manifest different degrees of ease of solubility, which may serve for their recognition.

*b. Incrustation of oxide* is produced by holding a porcelain capsule, filled with cold water, in the *upper oxidizing flame*, and proceeding in the same direction as for the production of a metallic incrustation. If but a small particle of the substance is employed for the test, the lamp-flame must be proportionally diminished, so that the products of volatilization do not spread too much over the porcelain surface.

The incrustation of oxide is tested in the following manner:—

*b′*. Its color is noticed as well as that of the coating.

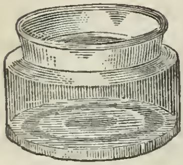
*b″*. It must be determined whether a drop of proto-chloride of tin effects a reduction.

*b‴*. If no reduction takes place, caustic soda is added to the protochloride of tin until the precipitated hydrated protoxide of tin is dissolved, and it is noticed whether a reduction then takes place.

*b⁗*. A drop of perfectly neutral hydrate of silver is spread, by means of a glass rod, upon the incrustation, and a stream of ammoniacal air blown upon it by means of a small wash-bottle, containing solution of ammonia, in which the mouth-tube dips beneath the liquid, and the exit-tube only extends below the cork. If a precipitate occurs, its color must be noticed, and also whether it dissolves, or what changes it may otherwise suffer when treated with a current of ammoniacal air for some time, or when solution of ammonia is dropped upon it.

*c. Incrustation of iodide.* This is formed in a simple way, out of the incrustation of oxide, by breathing upon the cooled capsule upon which the latter is found, and placing it upon the wide-mouthed, accurately stoppered glass vessel, Fig. 8, which contains iodide of phosphorous converted by deliquescence into fuming hydriodic and phosphorous acids. If the mixture ceases to fume by reason of absorption of water, it is only necessary to add some anhydrous phosphoric acid to render it fuming again. Heavier incrustations, often consisting of a mixture of iodide and subiodide, and therefore less uniform, can be produced by fuming the incrustations of oxide by means of a concentrated solution of iodine in alcohol, which is passed whilst burning, by means of a bunch of asbestus fastened to a platinum wire, back and forth under the capsule, still filled with cold water. If some dilute hydriodic acid, rendered brown by iodine, also condenses at the same time upon the capsule, it is volatilized by *gently* warming and blowing upon it.

Fig. 8.



The testing of the incrustation consists in the following:—

*c*′. Its solubility is tested simply by breathing upon it as soon as the capsule has become cold, whereupon its color changes or disappears entirely as it dissolves in the moisture of the breath. If the capsule is gently warmed, or blown upon at a short distance, the incrustation, dried by the current of air, reappears unchanged.

*c*″. The ammonia compound of the iodide, is formed by blowing upon the latter ammoniacal air, and noticing thereby whether the color of the incrustation and coating disappears rapidly or slowly or not at all, or whether changes of color are produced. The different coloration reappears instantly, if the capsule is placed for a few moments upon the mouth of a vessel containing fuming hydrochloric acid.

*c*‴. The incrustation of iodide also usually gives, with nitrate of silver and ammonia, as well as the proto-chloride of tin and hydrate of soda, the same reactions as the incrustation of oxide.

*d. Incrustation of sulphide* is most easily produced from the incrustation of iodide, by blowing upon it a current of air containing sulphide of ammonium, and removing the excess of sulphide of ammonium by *gently* warming the porcelain. It is advisable, whilst blowing upon it, to breathe from time to time upon the forming incrustation of sulphide. The following experiments are to be made with the incrustation:—

*d*′. By breathing upon it or dropping water upon it, it is determined whether it is soluble. The incrustations of sulphide often have precisely the same color as the corresponding incrustation of iodide, in which case they can generally be distinguished from the latter, by their insolubility when breathed upon.

*d''*. The solubility of the sulphide in sulphide of ammonium is tested by blowing or dropping it upon the incrustation.

4. *Incrustations on test-tubes.* Under some circumstances, it is advantageous to collect the incrustation from reduction upon the lower part of a large test-tube half filled with water, Fig. 5, D, especially when it is desirable to accumulate a considerable quantity of the reduction incrustation for further experiments. The fine asbestus fibre, with the test-specimen adhering to it, Fig. 5, *d*, is fixed, by means of the glass tube, *b*, as a support, before the lamp, as high as the middle of the upper reducing flame; the test-tube is then placed, by means of the movable support, B, Fig. 5, so that the bottom may be immediately over the asbestus fibre. By shoving the lamp under the test-tube, then, the asbestus fibre, with the test-specimen, will be found in the reducing flame.

According to the length of the time the apparatus is allowed to remain in this position, during which the test-specimen on the asbestus fibre is necessarily renewed, deposits of any desired thickness can be obtained. Since the water soon begins to boil, a few pieces of marble are placed with it in the test-tube to prevent violent ebullition.

## III.—REACTIONS OF SUBSTANCES.

Substances immediately recognizable by the flame reactions are divided most advantageously according to their behaviour upon oxidation and reduction into the following groups and subgroups:—

A. Substances reducible to metal, volatile, separable as incrustations.

1. Incrustations scarcely soluble in cold dilute nitric acid*—Tellurium, selenium, antimony, arsenic.

2. Incrustations slowly and difficultly soluble in cold dilute nitric acid—Bismuth, quicksilver, thallium.

3. Incrustations instantly soluble in cold dilute nitric acid—Cadmium, zinc, indium.

B. Metals that do not give incrustations, but are separated in the regular form.

1. Not fusible to globules upon reduction—*a.* Magnetic iron, nickel, cobalt. *b.* Non-magnetic palladium, platinum, rhodium, iridium.

2. Fusible to globules upon reduction—Copper, tin, silver, gold.

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* Containing twenty per cent. anhydrous acid.

c. Substances separable and recognizable most easy as compounds—Tungsten, titanium, tantalum and niobium; silicon, chromium, vanadium, manganese, uranium, sulphur, phosphorous.

I will now give the special reactions of the substances arranged in these groups.

( To be continued.)

# EDUCATIONAL

## THE MAGNESIUM LAMP.

By Albert R. Leeds.

For some time after I had received a Magnesium Lamp from the American Magnesium Company, I was deterred by irregularities in its performance from bringing it into frequent use. The blade of the key had been forced between the springs which clip the axle of the fan-wheel broadside, by some one unacquainted with the lamp, instead of edgewise, and the springs had thus become so far impaired as not to arrest the motion promptly. I have now, however, properly adjusted them, and find the starting and stopping of the lamp to be perfectly under control. Some difficulties still remain. In one instance, a piece of unburnt ribbon became jammed between the knife-edges of the wheels which remove the ashes, and arrested the clock. The lamp may go out from some unknown cause, a powerful draft in the chimney perhaps, or an imperfection in the material of the ribbon, or perchance a too rapid combustion. These difficulties are vanishing one after another, by perseverance in the use of the instrument; and even with the drawbacks mentioned above, I find the lamp to come more frequently and advantageously into use, in delivering courses of popular lectures on natural philosophy and chemistry, than any other piece of apparatus.

Many experiments of much scientific value fail to excite the interest expected by the lecturer on account of an utter inability in the hearers to see what is taking place—as, for example, the Mercurial Rain. But if a black cloth be hung upon the back of the receiver, and the lamp be turned towards it, the falling of the brilliantly illuminated spheres of mercury through the vacuum, becomes a striking spectacle. So, also, if it be desired to show that the expansion of the air in a receiver placed upon the plate of an air-pump, absorbs sufficient heat to condense the vapor, the opening of the lamp may be placed almost in contact with the sides of the vessel and the powerful cone of diverging rays thus obtained will show the clouds in the receiver rising and falling, and lit up with the prismatic colors. Or, by allowing the air previously compressed into a condensing chamber to escape freely into the atmosphere, its course will be traced by the rays of the lamp as a cone of vapor. No thermo-electric pile is requisite for the exhibition of this valuable experiment upon the absorption of heat.

When the lamp has been used for some time without the flexible chimney, a considerable amount of magnesia becomes diffused through the room, which serves to mark out in a striking manner the rectilinear course of rays of light,—diverging and converging cones,—the focussing of rays taken from the outer portions of lenses, the different positions of foci, the reflection of light from plane surfaces and from spherical and parabolic mirrors. It happens not unfrequently that the employment of the lantern for a few moments would be desirable, in order to learn whether a lantern illustration which it is intended to use, would be a satisfactory one, or perhaps the lantern would be useful for a short time in a lecture. If it is necessary to consume all the time and material requisite to prepare the mixed gases, the experiment goes untried. The subject of capillarity, for example, might be alluded to, and it would be desirable to show that the level of a liquid is elevated between two plates—the very nature of the action prevents it from becoming visible except on close examination. On the contrary, when set in the lantern, the equilateral hyperbola may be exhibited in faultless symmetry of form, as a curve of 20 feet or more in length; or, if it be desired to exhibit upon the screen the expansion of water in a thermometer bulb, when the temperature has fallen below 39° F., or the convection of heat by the rising of colored liquid from the bottom of a glass tank under the action of a coil of platinum wire heated by a galvanic current—one of Prof. Morton's beautiful experiments—or the electrolysis of water, salt, iodide of potassium, etc.; for all these purposes the occasional use of the Magnesium Lamp is invaluable. It is a great saving of trouble, and adds very much to the interest of a lecture to put a photographic etching, or an Indian ink drawing into the lantern, instead of preparing a large diagram, which, after all, is less visible. Less trouble, I mean, when no pressures are to be arranged, no lime cylinder to be put into position, and no waiting for air to blow out of tubes.

It is desirable sometimes to set the lantern in unusual positions, far back in a room where press-boards could not be conveniently arranged, or near the ceiling, as in the experiment of the Total Reflection of Light in a Liquid Vein, in either case requiring unusual connections and increased length of tubing. All this trouble is obviated by the Magnesium Lamp.

The ease with which the light is focussed, as compared with that from the lime cylinder, is another feature of practical advantage. I have three lanterns, into any one of which I place the lamp, adjusting its level by a block of wood or book and a piece of card-board with surprising facility. The lantern-box, indeed, is not necessary. A strip of wood on which to place the lamp, and carrying one upright piece for the condensers and another movable upright for the object-glass, is a better arrangement. A hood prevents escape of stray light. At some leisure moment, I shall try the Magnesium Lamp in the Polariscope to determine whether its illumination is sufficiently strong and steady to give satisfactory results.

## WHAT IS CIVIL ENGINEERING? WHAT, A CIVIL ENGINEER? AND WHAT, THEREFORE, MUST A PROFESSOR OF CIVIL ENGINEERING BE?

(Continued from vol. liv., page 423.)

[Note —In consequence of an unauthorized liberty taken by our printer, in arranging his matter according to physical principles of extension and figure, in place of the literary laws of meaning and continuity, Professor Warren's article appeared in our Dec. number mutilated in a manner which occasioned us the greatest mortification. A portion of the title was cut out and half the last paragraph was omitted, without even a "To be continued" being inserted. This was done after the proof had been duly corrected, and thus escaped our notice until the number was in circulation. For the encouragement of our contributors we may state, that though (from its very unprecedented character) such a performance might occur once it cannot happen twice.—Editor.]

IV. *Professor of Descriptive Geometry and Stereotomy*, the latter being comprehensively the art of shaping the component members of a proposed structure to their intended places, and of shaping forms generally, to fulfill given conditions, as in the construction of *shadows* corresponding to different bodies and circumstances of illumination; the construction of *perspectives*, agreeing with different conditions of form, distance, and direction in the object represented; *stone-cutting;* and the shaping of mechanical members to produce certain motions; or *cinematics.*

V. *Professor of Geodesy and Engineering Astronomy.*

VI. *Professor of Experimental Physics.*

*b. Auxiliary or Collateral Professorships*, resident or non-resident teaching by book or lecture, and with or without daily interrogation.

I. *Professor of Chemistry and Mineralogy.*

II. *Professor of Natural History, Geology, and Physical Geography* (in charge of practical meteorology).

III. *Professor of Modern* (foreign) *Languages.*

IV. *Professor of English Language and Literature* (non-resident lecturer).

V. *Professor of Mental and Moral Philosophy and Aesthetics* (non-resident lecturer).

VI. *Professor of Engineering Law and Political Economy* (non-resident lecturer).

VII. *Professor of Free Drawing and Modelling.*

VIII. *Professor of Anatomy and Physiology and Physical Culture.*

Thus we see, that, so far from its being possible for a single individual to be duly a "professor of civil engineering," a faculty of engineering should embrace no less than six fundamental professorships, and that the main body alone of engineering science, to which all its other parts are tributary, viz: mechanics, affords matter for two professorships.

We merely add in passing, that the subordinate character of the second group of professorships is, of course, not absolute, but relative, in connection with engineering construction, exclusive of mining engineering. In a school of mines, and in other institutions, those departments which are secondary here, would be primary, and even divisible, like mechanics in the present case, among two or more professors.

Hoping now that these views have been so acceptably explained to commend them to sound reason, and thus, so as to promote the just observance of true principles in the organization of schools for engineers and other professional technists in this land, we contribute them in behalf of the real, because well-grounded, success of these schools, which, indeed, are being more and more cherished both by the scientific, and the enlightened popular mind of the nation.

Troy, September, 1867.

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# CIVIL ENGINEERING.

## ITS SCOPE AND AIM, AND THE PROFESSORSHIP OF IT.

By S. Edward Warren, C. E.,
Professor of Descriptive Geometry, etc., Rens. Pol. Institute, Troy, N. Y.

Civilization is both the recognition and the realization of individual good, in and through the general good; as well as the general good, in the sum of individual good.

The *recognition*, alone, is *potential* civilization; *subjective*, or in the mind of the thinker.

The *realization*, alone, is *actual* civilization.

The full recognition and realization united, and by all, constitutes complete and perfect civilization.

War, on the contrary, is an agency for securing certain real or supposed good to some, by nothing less than the utter destruction of others.

While, therefore, war is the physical expression of the conflict of ideas and purposes, and the extreme form of the convulsions incident to the mighty transformation of humanity from a state of barbarism to that of civilization, yet, in proportion as civilization is actually attained, appreciated and loved, is war deplored, and resorted to only to defend existing civilization from fearful damage, or positive loss.

No opposites, therefore, can be more strongly contrasted than are war and finished civilization.

These preliminary principles are of service in defining civil engineering, both separately, and by exhibiting it against the background of an idea of totally different hue.

Civil engineering, then, is the determinate application of the laws of matter, form, and force, in the direction and disposition of matter, and the employment of forces, favorably to civilization.

And again, civil engineering is that which is opposed to military engineering, inasmuch as the latter contemplates the destruction of existing material fruits of civilization, even though it be only the destruction of a part in order to save the rest.

Civil engineering is only, in spirit and purpose, *constructive*. Military engineering is principally *destructive*, and at best only conservative.

So much being now secured in general terms, we bring to bear upon our thoughts the remembrance of the breadth, and depth, and multiformity, and complexity of present civilization, and the consequently limited portion of its wants to which any one agent can thoroughly minister. We are then led to seek out a suitable number of real and co-ordinate divisions of civil engineering, each of which shall he broad enough to constitute a field for life-long professional practice.

These would seem to be—

*Road Engineering*, embracing the reconnoissance, survey, location, calculation, construction and maintenance of steam and common roads, with the design, involving mathematical investigations, and the erection, of all their auxiliaries and accompaniments, viz: wood, stone, and iron bridges in all the different systems of each, tunnels, retaining walls, etc.

*Hydraulic Engineering*, embracing the like particulars, relative to canals, water-works, town and city sewerage, and drainage generally, river and harbor improvements, and works for irrigation.

*Mechanical Engineering*, embracing the design, erection and superintendence of water, wind, steam, or other motors, and of mills, mill work and machines generally.

*Topographical Engineering*, embracing the conduct of those higher operations of geodesy, engineering astronomy, and the incident elevated computations; in which the sphericity of the earth is regarded; and a higher, and, in part, a different class of instruments is employed from what is necessary in the previous departments.

*Mining Engineering*, embracing geological surveys, and the exploitation, survey, opening and superintendence of mines; and the design, erection and management of works for the reduction of mining products.

In a former article (see the December number of this *Journal*), we contemplated civil engineering on its scholastic or educational side, and saw the impossibility of any one person's teaching all that immediately constitutes a knowledge of it.

We now contemplate the same subject on its practical or executive side, and plainly see that the engineer's solution of the numerous great and varied problems of his profession, cannot properly be empirical, a mere blind following of rules deduced for him by geometers and analysts, or a blind experimental groping after a lucky result.

His work is the determinate and intelligent application of the laws of matter, form, and force to the accomplishment of his purposes.

He must therefore understand the laws of matter, the properties of form, and the doctrines of force. All these are capable of exact quantitative expression, agreeably to definite given conditions; and mathematics, as the science of quantity, furnishes the means for their expression. Moreover, as the action of forces may be endlessly varied by the imposition of various conditions, the *science of mechanics*, which discusses their action, both absolutely, and as acting in and through matter, and modified by the properties of matter, is a *subject of indefinite extent.* Also, as the problems of forces are often very complex, from the number and character of the conditions under which the forces act, the science of mechanics is not only of vast extent, but of great profundity, requiring the best service that pure mathematics can bring to its aid.

We dwell a moment longer on this point—the magnitude of the science of mechanics; because, in view of the scanty instruction on the subject in ordinary American collegiate education, together with the absence, in this country, until recently, of well-developed *professional* schools of technical science, it is probable that it is precisely on this point that the greatest popular misapprehension prevails among the great body of merely college men. And yet a just apprehension of the magnitude of the subject of mechanics is most vital to a true apprehension of the range and scope of engineering study and qualification.

But what can we say? To transcribe the table of contents of really elevated works on rational and technical mechanics, would afford little real information. We must then adopt the method of simply referring to examples, such as the works of Bartlett, Pierce, Weisbach, Mosely, Rankine, and the prominent French writers; to the programme of over eighty lectures on the subject, in the Polytechnic School at Paris, based on requirements in mathematics and mechanics, for admission, which it would require a very respectable mathematician to fulfill; and, finally, to the almost continuous study of this subject and its applications, *mathematically treated*, for a year and a half, in our oldest American scientific school.

With this final reference to examples, added to the previous reflections, may we not innocently, nay, more, usefully say, that the acceptance of the nomenclature "professorship of civil engineering" as *logically fit*, I mean, rather than *provisionally expedient* only, comes to just this: it is a test of the standards of thought prevailing at any given time and place, as to what civil engineering knowledge really is; and, consequently, of the real standard of instruction in it, actually adopted.

We say this in admiring view of what able and devoted American pioneers, concentrating their efforts on small classes, have been able to accomplish in teaching many of the components of engineering knowledge; but, in turning from the imperfectly developed actual to the ideal, now fairly attainable in more places than one, we declare the nomenclature alluded to to be a mainly unintelligible misnomer; and earnestly hope that the uprising company of schools of science based on the national land grants, and all others, also, will reject it, and designate the several *essential* members of a proper *faculty of engineering*, by the component subjects which they teach, and each of which subjects, taught as fully and as faithfully to the student, as a due standard of engineering education demands, is abundant to duly fill one professor's time.

In our former article, mention was made of several possible meanings which might attach to the words "professorships of civil engineering." Thus, a long course of instruction could be given, purely descriptive of the practical expedients adopted, and operations conducted, in the actual erection of engineering structures from foundation to coping stone. But such a course, though invaluable, if only to bring the student-mind into contact with fresh engineering practice, would be but a fragment of the total of engineering tuition. Yet, for the five broad divisions of civil engineering already described, it would well fill one instructor's time.

On the lowest legitimate view, a professorship of civil engineering should embrace the analytical investigation of the strains on each of the members of every important species of engineering structure; in other words, the application of pure, or rational mechanics, to the determination of the principles of the stability of structures.

But even this knowledge, added to that of the means and methods of constructive practice, is not all that it is *essential for an engineer to know.* Wherefore, these last words are those on which the whole question turns; and we feel free to adhere to the broader view, and to announce it as a demonstrated proposition, that any officer of instruction, in a school for professional scientific training, who teaches anything *which it is essential for an engineer to know*, is, to that extent, a "professor of civil engineering," and a member of a duly constituted faculty of engineering.

In now dismissing the subject for the present at least, we have only to add, that in discussing it, we hope we have expressed no unjust or unwelcome thought.

Rens. Pol. Inst., Nov. 1867.

# Franklin Institute.

### Proceedings of the Stated Monthly Meeting, December 18th, 1867.

The meeting was called to order with the President, Mr. J. Vaughan Merrick, in the chair.

The minutes of the last meeting were read and approved.

The Actuary submitted the minutes of the Board of Managers, with the following abstract of the proceedings at their stated meeting, held December 11th, 1867.

The special committee appointed to prepare resolutions to be presented at the next stated meeting of the Institute for adoption, in reference to the death of Prof. Faraday, reported the following preamble and resolutions, viz:—

Whereas, Formal notification having been received by the Franklin Institute, from the Royal Society, of the decease of Professor M. Faraday, it seems appropriate to the Board of Managers that the following resolution should be offered to the Institute at its stated meeting:—

*Resolved*, That the Institute recognizes in the death of Professor Faraday a serious loss to the progress of science, which owes so much in various departments to his genius and industry.

*Resolved*, That the name of Professor Faraday should be cherished and honored as second to none of those which have adorned the annals of science.

*Resolved*, That a copy of these resolutions shall be officially transmitted to the Royal Society of Great Britain.

On motion it was

*Resolved*, That it is expedient that an exhibition of American Arts and Manufactures should be held during the year 1868 in the city of Philadelphia by the Franklin Institute, and that the President be requested to appoint a special committee to take the subject into consideration, and report at the next meeting of the Board with reference to obtaining suitable accommodation therefor, and an appropriate plan of action to be pursued.

The resignation of membership in the Board by Messrs. E. Y. Townsend, Charles H. Crump, and John Rice were accepted.

Donations to the Library were received from the Institute of Actuaries and Society of Arts, London; Commodore F. A. Jenkins, U.S.N., Chief of the Bureau of Navigation; Frederick Emerick, Esq., Washington, D.C.; Stephen P. Sharpless, Esq., Cambridge, Mass.; Messrs. Joel Giles, Josiah Copley, R. S. Menamin, Edward Shippen, and Chas. Macdonald Philadelphia.

The various Standing Committees reported their minutes, and the Committee on Experiments in Steam Expansion reported progress.

A paper by Mr. Thos. Dunn, on the Construction of Iron Bridges without Scaffolding, was then read by the Secretary. The Secretary's Report on Novelties in Science and the Mechanic Arts was read.

The following nominations of candidates for officers for the ensuing year were then made:—

For President, J. Vaughan Merrick; Vice-President, Professor Robert E. Rogers; Treasurer, Mr. Frederick Fraley; Secretary, Professor Henry Morton; Auditor, Mr. William Biddle; Board of Managers, William B. Le Van, Percival Roberts, Jacob Naylor, Alex. Ervine, Samuel Sartain, Henry A. Bower, O. H. Wilson, Robert H. Long, Charles Bullock, J. H. Lenville, E. Longstreth, W. B. Wilstach, Enoch Lewis, R. A. Tilghman, Jacob G. Neafie, Barton M. Jenks.

The President then appointed the following gentlemen as Judges of Election: William A. Rolin, C. S. Bement, Samuel Hart, Hector Orr, M. C. Haines.

The meeting was then, on motion, adjourned.

HENRY MORTON, *Secretary.*

# Bibliographical Notice.

*Lessons in Elementary Chemistry, Inorganic and Organic.* By Henry G. Roscoe, B. A., F. R. S., Professor of Chemistry in Owens College, Manchester. London: Macmillan & Co.

A book, poor in typography, and with mean woodcuts, the latter being the worst specimens of engravings that we have ever seen. It is not written in such a manner as to attract beginners in the science of chemistry, much that is technical being introduced, to the exclusion of the details concerning experiments with oxygen, hydrogen, etc., which usually and very properly find their place in an elementary treatise.

*Williamson's Chemistry for Students* is a work deserving of high praise. The woodcuts, without being specimens of art, are clean and striking, while the general appearance of the printed page is very pleasing. It is especially valuable for its clear enunciation of the principles of modern chemistry, and for their consistent application to chemical problems and formulæ. The subjects of specific heat, heat of combination, the effects of pressure upon boiling-points, etc., are succinctly stated, and numerical examples given. Appended to the first twenty chapters are a skillfully framed series of problems, which are well calculated to familiarize the student with the metric system of weights and measures, the use of centigrade degrees, the calculation of vapor volumes at different temperatures and pressures, &c. The book is amply deserving of long-continued study, as being sufficient to place the student fairly upon the field wherein the labors of chemists of the present day are to be performed. We might suggest, that the process given for the manufacture of oxygen would almost inevitably burst the retort, and that the paragraph upon ozone is exceptional in falling behind our present knowledge of the subject. Although the arrangement of the chapters does not appear to us to be the one best adapted to their wants, yet it gives us great pleasure to recommend the work to *advanced* students of chemistry.

A COMPARISON *of some of the Meteorological Phenomena of* DECEMBER, 1867, *with those of* DECEMBER, 1866, *and of the same month for* SEVENTEEN *years, at Philadelphia, Pa.* Barometer 60 feet above mean tide in the Delaware River. Latitude 39° 57½′ N.; Longitude 75° 11¼′ W. from Greenwich. By PROFESSOR J. A. KIRKPATRICK, of the Central High School.

| | December, 1867. | December, 1866. | December, for 17 years. |
|---|---|---|---|
| Thermometer—Highest—degree. ......... | 52·50 | 61·00 | 71·00 |
| " date. ............ | 27th. | 8th. | 2d, '59. |
| Warmest day—mean .. | 47·33 | 57·00 | 62·80 |
| " " date...... | 28th. | 8th. | 2d, '59. |
| Lowest—degree . ......... | 8 00 | 6 00 | 4 50 |
| " date ...... ....... | 12th & 14th. | 21st. | 19th, '56. |
| Coldest day—mean ...... | 14·17 | 15 33 | 11·00 |
| " " date ....... | 13th. | 21st. | 18th, '56. |
| Mean daily oscillation... | 11·84 | 12·10 | 12·09 |
| " " range......... | 6 16 | 6·83 | 6·48 |
| Means at 7 A. M. ......... | 29·26 | 31·58 | 31·84 |
| " 2 P. M. ......... | 34·13 | 37·18 | 38 88 |
| " 9 P. M . ......... | 31·77 | 34·19 | 34·62 |
| " for the month.... | 31·72 | 34·32 | 35·11 |
| Barometer—Highest—inches...... ......... | 30 558 | ......... ......... | 30 678 |
| " date......... ......... | 19th. | ......... ......... | 18th, '56. |
| Greatest mean daily pressure | 30·516 | ........... ...... | 3 ·611 |
| " " " date... | 19th. | ..................... | 18th, '56. |
| Lowest—inches ...... ......... | 29·548 | ..................... | 28 946 |
| " date ...... ..... ...... | 6th. | ......... ......... | 9th, '55. |
| Least mean daily pressure... | 29·704 | ......... ......... | 29·175 |
| " " " date... | 17th. | ..................... | 9th, '54. |
| Mean daily range.............. | 0·256 | ..................... | 0·217 |
| Means at 7 A. M .............. | 30 038 | ..................... | 29·955 |
| " 2 P. M ........ ...... | 30·027 | ..................... | 29 914 |
| " 9 P. M ...... ........ | 30·032 | ......... ......... | 29·942 |
| " for the month......... | 30·052 | ..................... | 29 937 |
| Force of Vapor—Greatest—inches ....... | 0·361 | 0·472 | 0·551 |
| " date . ......... | 27th. | 8th. | 2d, '59. |
| Least—inches............ | 055 | ·042 | ·025 |
| " date................ | 13th. | 20th. | 18th, '56. |
| Means at 7 A. M ......... | ·133 | ·152 | ·145 |
| " 2 P. M ......... | ·131 | ·153 | ·165 |
| " 9 P. M ........ | ·146 | ·165 | ·157 |
| " for the month... | ·137 | ·157 | ·156 |
| Relative Humidity—Greatest—per cent | 93·0 | 96 0 | 100·0 |
| " date...... | 12th & 27th. | 16th. | Often. |
| Least—per cent.... | 41 0 | 35·0 | 23·0 |
| " date......... | 29th. | 9th. | 15th, '61. |
| Means at 7 A. M.... | 78·5 | 79 4 | 77 6 |
| " 2 P M.... | 65·1 | 64 5 | 65·2 |
| " 9 P. M.... | 77·1 | 76 9 | 75 3 |
| " for the month | 73·6 | 73 6 | 72·7 |
| Clouds—Number of clear days*. ......... | 5· | 14· | 8 6 |
| " cloudy days ......... | 26· | 17· | 22·4 |
| Means of sky covered at 7 A. M | 72·9 per ct | 46·4 per ct | 64·1 per ct |
| " " " 2 P. M | 70·6 | 56 4 | 63·7 |
| " " " 9 P. M | 52·6 | 42 6 | 49 0 |
| " " for the month | 65·4 | 48 5 | 58·9 |
| Rain and melted snow—Amount—inches | 2·860 | 3 522 | 3·765 |
| No. of days on which rain or snow fell ... | 12. | 9· | 10·6 |
| Prevailing Winds—Times in 1000. ...... | N52°46′W·201 | N78°16′W·351 | N68°24′W·26 |

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* Sky one-third or less covered at the hours of observation.

A COMPARISON *of some of the Meteorological Phenomena of the year* 1867, *with those of* 1866, *and of the last* SIXTEEN *years, at Philadelphia, Pa.* Barometer 60 feet above mean tide in the Delaware River. Latitude 39° 57½′ N.; Longitude 75° 11¼′ W. from Greenwich. By PROF. J. A. KIRKPATRICK, A. M., of the Central High School.

| | 1867. | 1866. | 16 years. |
|---|---|---|---|
| Thermometer—Highest—degree.......... | 91·00 | 101·00 | 101·00 |
| “ date............. | July 4. | July 17. | July 17, '66 |
| Warmest day—mean.... | 85·67 | 92·33 | 92 33 |
| “ “ date...... | July 4. | July 17. | July 17, '66. |
| Lowest—degree. ......... | 8·00 | —9·00 | —9 00 |
| “ date...... ...... | Dec. 12 & 14. | Jan. 8. | Jan. 8, '66. |
| Coldest day—mean ...... | 14·17 | 2·67 | —1·00 |
| “ “ date ....... | Dec. 13. | Jan. 8. | Jan. 9, '56. |
| Mean daily oscillation... | 14·48 | 13·91 | 14·77 |
| “ “ range......... | 5·30 | 5·80 | 5·53 |
| Means at 7 A. M....... ... | 49·27 | 50·67 | 49·94 |
| “ 2 P. M ......... | 58·17 | 60 02 | 59·82 |
| “ 9 P. M ......... | 52·78 | 54·00 | 53·31 |
| “ for the year ....... | 53·41 | 54·90 | 54·36 |
| Barometer—Highest—inches............. | 30·970 | 30·757 | 30·970 |
| “ date......... ......... | Feb. 11. | Jan. 8. | Feb. 11, '67. |
| Greatest mean daily pressure | 30·862 | 30·665 | 30 862 |
| “ “ “ date... | Feb. 11. | Jan. 8. | Feb. 11, '67. |
| Lowest—inches ...... ......... | 28·778 | 28·820 | 28·778 |
| “ date............ ...... | May 8. | April 23. | May, 8, '67. |
| Least mean daily pressure. | 29·013 | 29,051 | 28·958 |
| “ “ “ date... | May 8. | April 23. | Ap'l 21, '52. |
| Mean daily range............. | 0·187 | 0·50 | 0·157 |
| Means at 7 A. M............... | 29 996 | 29·860 | 29·885 |
| “ 2 P. M............... | 29·962 | 29 809 | 29 844 |
| “ 9 P. M...... ......... | 29·977 | 29·842 | 29·871 |
| “ for the year........... | 29·978 | 29·837 | 29·866 |
| Force of Vapor—Greatest—inches ....... | 0·925 | 0·980 | 1·059 |
| “ date. ......... | July 6. | July 17. | June 30, '55. |
| Least—inches ......... | 0·42 | ·024 | ·013 |
| “ date ...... ...... | Jan.. 30. | Jan. 8. | Feb. 6, '55. |
| Means at 7 A. M......... | ·316 | ·331 | ·324 |
| “ 2 P. M......... | ·325 | ·342 | ·339 |
| “ 9 P. M......... | ·341 | ·361 | ·346 |
| “ for the year...... | ·327 | ·345 | ·336 |
| Relative Humidity—Greatest—per cent | 100·0 | 100·0 | 100·0 |
| “ date...... | Oct. 29. | Jan. 15. | Often. |
| Least—per cent.... | 21·0 | 18·0 | 13·0 |
| “ date......... | Apr. 6. | April 29. | Ap'l 13, '52. |
| Means at 7 A. M.... | 75·6 | 74·9 | 75·5 |
| “ 2 P. M.... | 57·7 | 56·3 | 57·1 |
| “ 9 P. M.... | 71·9 | 72·8 | 72·0 |
| “ for the year...... | 68·4 | 68·0 | 68·2 |
| Clouds—Number of clear days*. ......... | 108· | 122· | 109· |
| “ cloudy days. ......... | 257· | 243· | 256· |
| Means of sky covered at 7 A. M | 62·9 per ct | 56 9 per ct | 60·1 per ct |
| “ “ “ 2 P. M | 61·9 | 59·8 | 60·9 |
| “ “ “ 9 P. M | 48·6 | 47·5 | 46·1 |
| “ “ for the year ...... | 57·8 | 54·7 | 55·7 |
| Rain and melted snow—Amount—inches | 62·935 | 43·573 | 46·926 |
| No. of days on which rain or snow fell... | 134· | 116· | 127· |
| Prevailing Winds—Times in 1000. ...... | N71°34′W·152 | N88°15′W315 | N75°12′W·198 |

* Sky one-third or less covered at the hours of observation.

## General Abstract of the Meteorological Observations made at Philadelphia during the Year 1867.

### By Prof. James A. Kirkpatrick.

*Lat.* 39° 57½′ *N.* *Long.* 75° 11¼′ *W. from Greenwich. Height of Bar. fount,* 60 *feet above mean tide in the Delaware River.*

| 1867. | Thermometer. | | | | | | | | | Barometer. | | | | | | | | Dew Point. | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | Range. | | | Means. | | | | | | Range. | | Means. | | | | Means. | | | |
| Months. | Maximum. | Minimum. | Monthly | Mean daily | Mean daily oscillation. | 7 A. M. | 2 P. M. | 9 P. M. | Average. | Highest. | Lowest. | Monthly | Mean daily | 7 A. M. | 2 P. M. | 9 P. M. | Average. | 7 A. M. | 2 P. M. | 9 P. M. | Average. |
| | ° | ° | ° | ° | ° | ° | ° | ° | ° | Inch. | Inch. | Inch. | Inch. | Inch. | Inch. | Inch. | Inch. | ° | ° | ° | ° |
| January | 42 | 9 | 33 | 5·03 | 10·61 | 23·29 | 29·29 | 26·23 | 26·27 | 30·443 | 29·337 | 1·106 | ·225 | 29·918 | 29·883 | 29·919 | 29·907 | 17·02 | 19·44 | 17·44 | 17·97 |
| February | 55 | 16½ | 38½ | 6·41 | 14·64 | 35·84 | 43·36 | 40·66 | 39·95 | 30·970 | 29·303 | 1·667 | ·279 | 30·087 | 30·053 | 30·065 | 30·068 | 29·15 | 29·56 | 32·30 | 30·34 |
| March | 61½ | 20 | 41½ | 5·63 | 12·64 | 34·14 | 41·29 | 37·32 | 37·58 | 30·485 | 29·430 | 1·055 | ·235 | 30·032 | 30·002 | 30·015 | 30·016 | 27·17 | 27·36 | 28·45 | 27·66 |
| April | 80 | 36 | 44 | 6·54 | 17·75 | 47·22 | 59·02 | 52·32 | 53·15 | 30·314 | 29·295 | 1·019 | ·234 | 29·966 | 29·896 | 29·931 | 29·931 | 34·75 | 35·34 | 37·65 | 35·91 |
| May | 87 | 36 | 51 | 5·30 | 17·64 | 54·10 | 64·92 | 56·50 | 58·53 | 30·423 | 28·778 | 1·645 | ·214 | 29·855 | 29·804 | 29·836 | 29·832 | 44·31 | 43·44 | 45·39 | 44·38 |
| June | 88 | 48 | 40 | 4·39 | 17·07 | 67·60 | 77·17 | 69·67 | 71·48 | 30·309 | 29·474 | ·835 | ·105 | 30·006 | 29·986 | 29·994 | 29·995 | 59·28 | 59·01 | 60·15 | 59·48 |
| July | 91 | 58 | 33 | 3·99 | 14·69 | 72·00 | 81·27 | 75·00 | 76·09 | 30·249 | 29·665 | ·584 | ·097 | 29·941 | 29·912 | 29·916 | 29·923 | 60·06 | 60·16 | 63·88 | 61·67 |
| August | 86 | 59 | 27 | 3·68 | 12·44 | 71·02 | 78·18 | 74·56 | 74·59 | 30·210 | 29·578 | ·632 | ·108 | 29·967 | 29·939 | 29·944 | 29·950 | 63·03 | 63·96 | 66·01 | 64·63 |
| September | 86 | 43 | 43 | 5·36 | 14·52 | 63·12 | 73·62 | 66·80 | 67·84 | 30·466 | 29·623 | ·843 | ·136 | 30·084 | 30·050 | 30·058 | 30·064 | 56·82 | 59·05 | 59·18 | 58·35 |
| October | 80 | 38 | 42 | 5·28 | 15·39 | 50·71 | 63·55 | 55·79 | 56·68 | 30·465 | 29·556 | ·909 | ·175 | 30·053 | 30·005 | 30·020 | 30·026 | 45·02 | 46·43 | 48·06 | 46·50 |
| November | 69 | 24 | 45 | 6·37 | 14·47 | 42·63 | 51·34 | 46·68 | 46·98 | 30·342 | 29·250 | 1·092 | ·182 | 30·006 | 29·972 | 29·994 | 29·991 | 37·18 | 38·68 | 39·34 | 38·40 |
| December | 52½ | 8 | 44½ | 6·16 | 11·84 | 29·26 | 34·13 | 31·77 | 31·72 | 30·558 | 29·548 | 1·010 | ·256 | 30·038 | 30·027 | 30·032 | 30·032 | 23·34 | 23·35 | 25·42 | 24·03 |
| Annual Means | 91 | 8 | 83 | 5·30 | 14·48 | 49·27 | 58·17 | 52·78 | 53·41 | 30·970 | 28·778 | 2·192 | ·187 | 29·996 | 29·962 | 29·977 | 29·978 | 41·58 | 42·15 | 43·60 | 42·44 |
| Winter | 61 | 6 | 55 | 6·10 | 12·45 | 30·27 | 36·61 | 33·69 | 33·52 | 30·970 | 29·303 | 1·667 | ·240 | 29·985 | 29·918 | 29·973 | 29·969 | 24·04 | 24·99 | 25·80 | 24·94 |
| Spring | 87 | 20 | 67 | 5·62 | 16·01 | 45·15 | 55·38 | 48·71 | 49·75 | 30·485 | 28·778 | 1·707 | ·228 | 29·951 | 29·904 | 29·927 | 29·927 | 35·41 | 35·38 | 37·16 | 35·98 |
| Summer | 91 | 48 | 43 | 4·02 | 14·73 | 70·21 | 78·87 | 73·08 | 74·05 | 30·309 | 29·474 | ·835 | ·103 | 29·971 | 29·946 | 29·951 | 29·956 | 61·39 | 61·01 | 63·35 | 61·93 |
| Autumn | 86 | 24 | 62 | 5·67 | 14·79 | 52·25 | 62·83 | 56·42 | 57·17 | 30·466 | 29·250 | 1·216 | ·164 | 30·048 | 30·009 | 30·024 | 30·027 | 46·34 | 48·05 | 48·86 | 47·75 |
| Means for 16 years | 101 | —9 | 110 | 5·53 | 11·77 | 49·94 | 59·82 | 53·31 | 54·36 | 30·970 | 28·778 | 2·192 | ·157 | 29·885 | 29·844 | 29·871 | 29·866 | ........ | 43·29 | ........ | ........ |

## TABLE (CONTINUED).

*A General Abstract of the Meteorological Observations made at Philadelphia during the year* 1867.

| 1867. | Relative Humidity. | | | | | | | Force of Vapor. | | | | | | | Clouds. Sky Covered. | | | | Rain or melted snow. | | Winds. | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | Means. | | | | | | | Means. | | | | Means. | | | | | | | |
| MONTHS. | Maximum. | Minimum. | Range. | 7 A. M. | 2 P. M. | 9 P. M. | Average. | Maximum. | Minimum. | Range. | 7 A. M. | 2 P. M. | 9 P. M. | Average. | 7 A. M. | 2 P. M. | 9 P. M. | Average. | Amount. | No. of days it f.ll. | Monthly resultant. | No. of times in 1000. |
| | Per ct. | Per ct. | Per ct. | Per ct. | Per ct. | Per ct. | Per ct. | Inch. | Inch. | Inch. | Inch. | Inch. | Inch. | Inch. | Per ct. | Per ct. | Per ct. | Per ct. | Inch. | Days | Direc. from. | |
| January..... | 94 | 40 | 54 | 76·3 | 66·3 | 68·7 | 70·4 | ·183 | 042 | ·141 | ·099 | ·109 | ·101 | ·103 | 52·9 | 60·0 | 42·9 | 51·9 | 1·925 | 8 | N. 69° 9′ W. | 424 |
| February ... | 95 | 27 | 68 | 76·8 | 60·2 | 72·7 | 69·9 | ·361 | ·049 | 3'2 | ·171 | ·174 | ·193 | .179 | 65·3 | 68·2 | 61·4 | 64·9 | 4·820 | 12 | S. 73 30 W. | 181 |
| March........ | 95 | 23 | 71 | 76·1 | 60·2 | 71·7 | 69·3 | ·333 | ·060 | ·273 | ·154 | ·159 | ·161 | ·158 | 75·1 | 74·2 | 61·9 | 70·4 | 5·670 | 18 | N. 7 51 E. | 340 |
| April. ........ | 94 | 21 | 73 | 63·0 | 42·6 | 59·3 | 55·0 | ·504 | ·074 | ·430 | ·213 | ·222 | ·241 | ·225 | 58·0 | 57·7 | 42·3 | 52·6 | 1·360 | 10 | S. 80 8 W. | 143 |
| May........... | 96 | 29 | 67 | 71·3 | 48·1 | 67·5 | 62·3 | ·625 | ·139 | ·486 | ·310 | ·305 | ·320 | ·312 | 62 8 | 67·9 | 50·0 | 60·2 | 7 070 | 12 | S. 82 24 W. | 99 |
| June ......... | 95 | 28 | 67 | 75·8 | 56·3 | 72·7 | 68·3 | ·789 | ·183 | ·615 | ·524 | ·521 | ·540 | ·528 | 66·3 | 61·7 | 52·7 | 60·2 | 10·950 | 11 | S. 36 52 W. | 59 |
| July.......... | 91 | 32 | 59 | 68·9 | 50·5 | 69·2 | 62·9 | ·925 | ·321 | ·604 | ·552 | ·543 | ·608 | ·568 | 52·2 | 59·3 | 43·2 | 51·6 | 3·030 | 12 | N. 69 35 W. | 268 |
| August........ | 92 | 39 | 53 | 78·7 | 63·4 | 75·2 | 72·4 | ·815 | ·317 | ·498 | ·602 | ·609 | ·645 | ·619 | 63 2 | 63·5 | 44·5 | 57·1 | 16·840 | 15 | S. 52 26 E. | 94 |
| September.. | 95 | 28 | 67 | 80·2 | 61·4 | 76·9 | 72·8 | ·812 | ·125 | ·687 | ·485 | ·531 | ·52 | ·514 | 66·3 | 49·3 | 41·7 | 52·5 | 1·850 | 7 | N. 69 46 W. | 125 |
| October....... | 100 | 33 | 67 | 81 3 | 55·3 | 75·9 | 70·8 | ·604 | ·142 | ·462 | ·315 | ·339 | ·350 | ·335 | 54·8 | 44·2 | 40 3 | 46 4 | 4·020 | 7 | N. 76 37 W. | 257 |
| November .. | 94 | 41 | 53 | 80·3 | 63 0 | 76·5 | 73·3 | ·548 | ·109 | ·448 | ·236 | ·256 | ·258 | ·250 | 65·0 | 66·0 | 50·0 | 60·3 | 2 540 | 10 | S. 76 32 W. | 261 |
| December... | 93 | 41 | 52 | 78·5 | 65·1 | 77·1 | 73·6 | ·361 | ·055 | ·306 | ·133 | ·131 | ·146 | ·137 | 72·9 | 70·6 | 52·6 | 65·4 | 2·860 | 12 | N. 52 46 W. | 201 |
| Ann. means. | 100 | 21 | 79 | 75·6 | 57 7 | 71·9 | 68·4 | ·925 | ·042 | ·883 | ·316 | ·325 | ·341 | ·327 | 62 9 | 61·9 | 48 6 | 57·8 | 62·935 | 134 | N. 71° 34′ W. | 152 |
| Winter ...... | 96 | 27 | 69 | 77·5 | 63·7 | 72·8 | 71·3 | ·472 | ·042 | ·430 | ·141 | ·145 | ·153 | ·146 | 54·9 | 61·5 | 49·0 | 55·1 | 10·267 | 29 | N. 78° 9′ W. | 313 |
| Spring........ | 96 | 21 | 75 | 70·1 | 50·3 | 66·2 | 62·2 | ·625 | ·060 | · 65 | ·226 | ·229 | ·241 | ·232 | 65·3 | 66·6 | 51·4 | 61 1 | 14·100 | 40 | N. 29 59 W. | 123 |
| Summer..... | 95 | 28 | 67 | 74·5 | 56·7 | 72·4 | 67·9 | ·925 | ·183 | ·742 | ·559 | ·558 | ·598 | ·572 | 60·6 | 61·5 | 46·8 | 56·3 | 30·820 | 38 | S. 86 49 W. | 71 |
| Autumn..... | 100 | 28 | 72 | 80·6 | 59·9 | 76·4 | 72·3 | ·812 | ·100 | .712 | ·345 | ·375 | ·379 | ·366 | 62·0 | 53·2 | 44·0 | 53·1 | 8·410 | 24 | N. 86 12 W. | 209 |
| Means for 16 years... | 100 | 13 | 87 | 75·5 | 57·1 | 72·0 | 68·2 | 1·059 | ·013 | 1·046 | ·324 | ·339 | ·346 | ·336 | 60·1 | 60 9 | 46·1 | 55·7 | 46·926 | 127 | N. 75° 12′ W. | 198 |

# JOURNAL

OF THE

# FRANKLIN INSTITUTE

OF THE STATE OF PENNSYLVANIA,

FOR THE

PROMOTION OF THE MECHANIC ARTS.

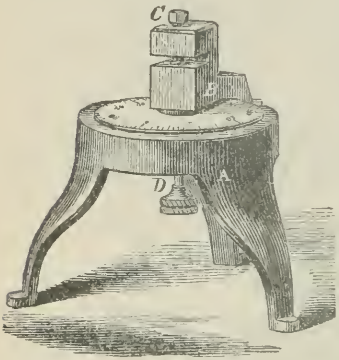
Vol. LV.] MARCH, 1868. [No. 3

# EDITORIAL.

## ITEMS AND NOVELTIES.

**A Sheet Metal Gauge,** made by J. R. Brown & Sharpe, Providence, R. I., was exhibited at the last meeting of the Franklin Institute.

The difficulty of measuring the thickness of sheet metals with accuracy is well known to all persons who have occasion to use or deal in them. The gauges commonly used having a series of fixed sizes determine the thickness only approximately, and, as the sizes wear by constant use, such gauges become still more unreliable. The edges of sheet metal being often imperfect, ordinary gauges are prevented from going on readily. It usually happens that the edges are thinner than the middle of the sheet, and the gauge cannot reach on far enough to measure the thickest part. In selecting sheet metals for many purposes, it is desirable to have a gauge to indicate the exact thickness in parts of an inch. To accomplish this result, the gauge shown in the engraving has been devised, which will give the thickness of a piece of metal up to one-quarter of an inch in thousandths of an inch, and at some distance from the edge of the sheet. The stand, A, supported upon three feet, with an upright, B, is a single casting. In this upright is a space or slot. Above this space, in the upright, is an adjusting screw, C. Fitted into the lower part of the upright is a screw, D, with a milled head on the lower end. Attached to this screw, and revolvingwith it, is a German-silver dial. The graduations on the edge of this dial are read off from an index point. The upper and lower screws are exactly in line with each other, and their points, which are hardened, meet in the space between the two. The threads upon the screw, D, are ten to one inch, and the edge of the dial is divided into one hundred parts. With this explanation of the position and relation of the several parts of the gauge, it will readily be perceived that when the metal to be measured is placed in the opening in the standard, and the screw, D, made to revolve until the metal is held between the ends of the screws, D, and the adjusting screw, then the exact thickness can be read off in thousandths of an inch at the index point. Should any wear of the points of the screws take place the point, 0, can always be kept exactly opposite the index point by means of the adjusting screw. A small binding screw, with a piece of brass under its point, serves to hold the adjusting screw firmly in its place, when it is set correctly. The accuracy and simplicity of this gauge will commend it to those who desire to obtain uniformity in the thickness of sheet metals, or in thin materials of any kind. It is particularly useful to machinists, jewelers, silversmiths, sheet-brass rollers and workers, sheet-iron rollers, rubber manufacturers, paper makers, and type founders.

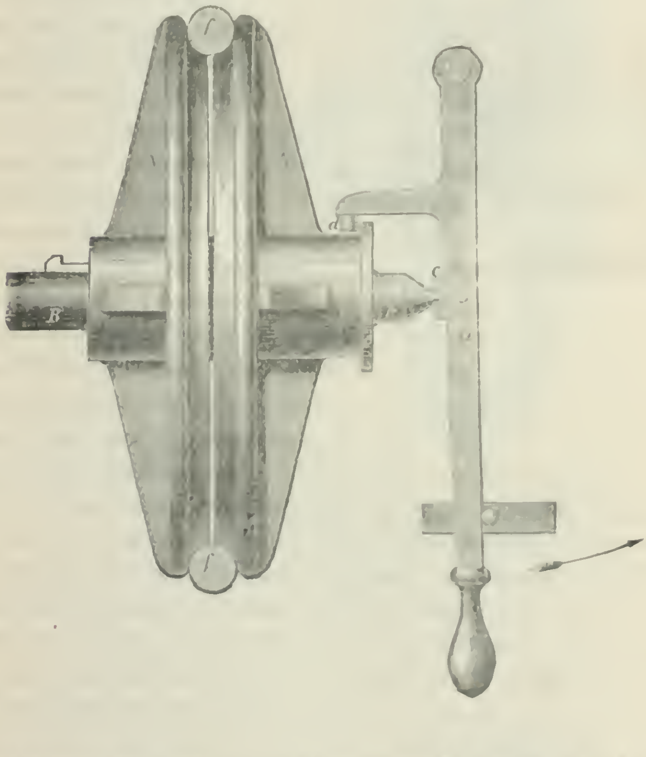


These gauges may be seen at the store of J. W. Queen & Co., 924 Chestnut street.

**Improved Clutch Pulley,** by John Shinn, of Philadelphia. In this apparatus, the object is to shift a belt from a loose to a fast pulley, with greater advantage, in many respects, than can be secured by the usual arrangement. We will first describe the apparatus, and then allude to its special claims to distinction.

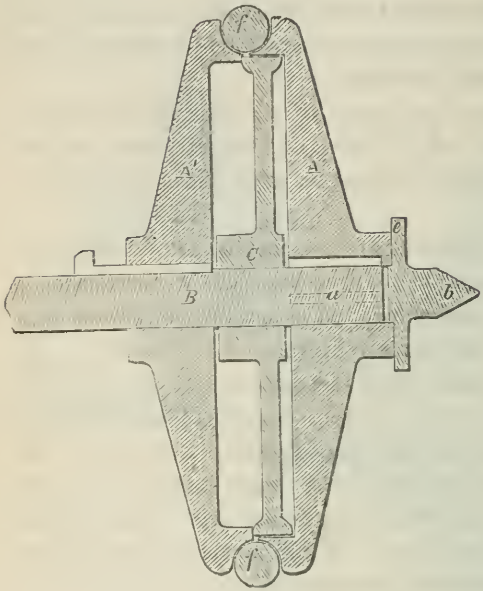
Two pulleys are arranged, as shown in the cuts at A and A′; both of these are fast pulleys, but while one A′ is keyed to the shaft B, the other, A, slides on a feather, by which means, its distance from A′ may be varied, and any desired amount of bite obtained upon the cord between their edges. The middle wheel, C, constitutes the loose pulley of this system, and the band comes upon this when the pulley A is caused to recede from A′, so as to let the cord come down between them.

*Fig. 1*



These motions of the pulley A are secured by means of the lever D, which bears upon the steel centre, b, of the wheel A, thus bringing the pulleys A′ and A together; and the pin and friction roller, *d*, bearing on the collar, *c*, by which the latter pulley is withdrawn from the other. Where it is desirable to bring the bite or grasp of the pulley upon the cord to a certain point, and there regulate it, the pressure is brought upon the wheel by a set-screw, with jam nut, attached to the lever, D, and bearing upon a depression in the plate, *e*, the steel centre, *b*, being removed.

*Fig 2*



The advantage of such an arrangement in the case of delicate machinery, is obvious. The tension is so adjusted that the hold of the cord is just sufficient to drive the apparatus; if, then, any derangement occurs by which the machinery if forced forward might be broken, the increased resistance makes the band slip, and no harm is done.

Thus, for example, in dying cotton warps, the yarn sometimes laps on the rollers under the dark colored solution in the vats, where it is therefore invisible, and before the mischief is discovered, a great quantity of valuable material may be destroyed.

We have heard of cases where $300 worth of yarn has thus been lost in a single day.

It is not proposed, of course, to drive very large and heavy machinery with round belts, such as are required for this description of shifting pulleys, but as far as a round belt will go with advantage (and this is very far), these pulleys will be found of the greatest service.

Thus, the round belt cuts off less light, occupies less room, makes smaller holes in the floors, requires lighter driving pulleys to carry it, and thus saves power; while as regards the driving power of round belts, we have seen one of an inch diameter, doing for years, work which proved too much for a seven-inch flat belt.

**The Brooks Insulator in France.**—In our issue of last July, we gave some account of the admirable improvement in telegraph insulators made by Mr. David Brooks, and we published the result of experiments made upon them, in comparison with others, by Dr. Charles M. Cresson. Since that time, the insulator, without a preliminary decease, has been, where other good Americans are reported to go after that event—to Paris.

We have now received the first news of its arrival and condition, from the French press. In *L'Union*, of February 4th, we find the following statements, which it gives us great pleasure to translate and publish.

"M. de Vougy, Director-General of Telegraphs, some time since appointed a commission specially charged with the examination of telegraph insulators of the most approved construction, with a view to the adoption of the best sort for our lines.

"This commission, provided with instruments of the greatest delicacy for detecting loss of the current by the insulators, have established the great superiority of the insulator devised by Mr. David Brooks, of Philadelphia, to all its competitors, and have ordered from him a large number to make an experiment, on the large scale, upon our telegraph lines." A description is here given, which we omit, because identical in substance with that we have already published, (Vol. IV., p. 10,) after which, as follows.

"Mr. Brooks, who is constantly engaged in connection with telegraphic constructions, and whose insulator is very well known in America, only arrived at the complete form, which we have just described, after many and continued experiments.

"It is clearly to the use of paraffine, long recognized as the first of insulating substances, that Mr. Brooks owes the success which he has obtained."

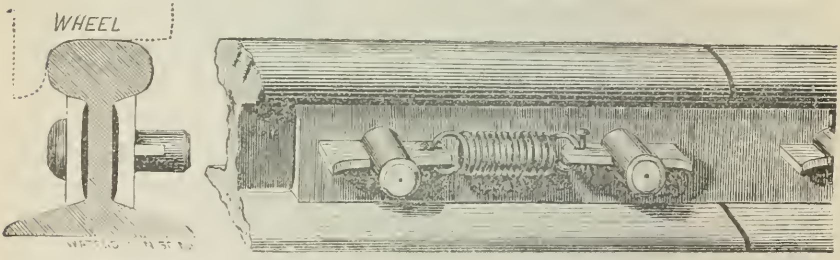
We may add, however, to this last, that though the insulating power of paraffine has been long known, its peculiar property of repelling moisture (to which its efficiency in this special application is mainly due,) has only been brought into notice by this very application made by Mr. Brooks.

From a private letter received from a gentleman who is one of the commission mentioned above, we learn that, in the actual trials referred to, the Brooks Insulator *excelled its next best rival fully one hundred times.*

**A Self-Tightening Steel Attachment** for railway joints, was exhibited at the last meeting of the Institute, by the Knox Railway

Clamp Company. This apparatus consists of two steel keys, a spring and two iron retaining pins, which, added to the bolts and plates, complete the *clamp.* The bolts, instead of being held by the usual thread and nut, are punched with smooth key-holes, and secured by tapering keys, the small ends of which are connected by a spiral spring, and made fast by the retaining pins, to prevent either the spring or keys being removing without proper tools, thereby making the fastening doubly secure. This spring is continually drawing the keys in, and tightening up the plates as fast as any wearing occurs between them and the rails, so that the working of the latter, by expansion or sliding, must necessarily wear off all scales and roughness.

The whole joint, eventually, becomes as perfectly fitted as the piston to an engine, so there is no possibility of the end of one rail being forced higher or lower than the other, thereby making a practically continuous track with a solid rail, and entirely doing away with the noise, so annoying to passengers, and saving thousands of dollars annually in rails, ties, engines, &c.



It is claimed that until the Knox Clamp was introduced, there has been no chair or joint made that has the self-perfecting feature of working tight, but, on the contrary, all get looser as they become worn. This arrangement is entirely independent of that for expansion and contraction, which is provided for by the elongated holes through the rails, so that each clamp allows for the expansion of its respective rail only, and is much safer than the ordinary lip-chair, which does not prevent the rails from sliding along and opening at a single joint from two to four inches, the result, oftentimes, of very serious accidents.

A peculiarity of this clamp is, that it tightens up when a train is passing over, which is the only time a joint is forced to its proper firm position.

One can hardly realize the importance of having a clamp or chair that will continually keep the ends of the two rails of the same height, unless he stands by the side of a track and watches a joint when a train is passing over at full speed; then, and only then, can he form any idea as to the force with which a wheel strikes the least projection of a rail, which cause alone has broken more wheels, thrown more trains off the track, destroyed more engines and cars, hammered out more ties, battered up and split more rails, than all other causes combined.

The plates for this clamp are generally punched with one-inch round holes, five inches apart from centre to centre.

Railway engineers have of late paid particular attention to having the rails for fishing made of the same angle and shape, under the shoulder or tread, that it has over the base or web, so the plates will fit exactly, if placed either side up by careless workmen.

These attachments are now being introduced on the Pennsylvania Central, Philadelphia and Reading, Chicago and North-Western Railroads.

**Effects of Heat on Infusoria.**—A very interesting but elaborate series of experiments on living organisms in heated water, is recorded by Professor Wyman, of Harvard College, in the September No. of Silliman's Journal. As the majority of these experiments are abstruse, entering into very exact descriptions, and noticing very minute differences, a full repetition of them would be tedious to any but those specially engaged in such investigations. We will therefore endeavor to give to our readers the deductions arrived at, and for the record of the experiments the above Journal may be referred to.

In the first place, we would state that there is a controversy existing as to whether the living animalculæ found in fluids are to be traced to "organisms or the germs of them contained in the fluid or in the air."

"Or whether they are to be attributed to the direct transformation of organic matter into new living beings independently of any germs or living organisms whatever," or, in other words, to "spontaneous generation." The object of these experiments is to settle the question whether the process of boiling the solution employed, would or would not destroy organisms or the germs that produce them.

Prof. Wyman has discovered that solutions of organic matter which had been boiled for nearly half an hour, and then exposed only to air which had been passed through red hot tubes, generated animalculæ. Again, solutions of organic matter were entirely exhausted of air and then hermetically sealed, after which their temperature was raised to the boiling point at periods of time varying from a few minutes to several hours; these also became the seat of infusorial life.

After the solutions had been boiled for a long time, no infusoria appeared. The living infusoria resist in a dry heat a much higher temperature than when moist; as high a heat even as 248° F. according to Doyer, failing to destroy their vitality.

**Tubes absolutely empty of Air.**—It was for a long time a question of dispute whether the electric spark would pass through an absolute vacuum.

Mr. Gassiot, as is well known, succeeded in constructing an apparatus through which the spark will not pass. He made the vacuum in this apparatus by filling it with carbonic acid and exhausting by the ordinary process. The residue is then slowly absorbed by means of caustic potash. M. M. Alvergniat Brothers, have succeeded in constructing an apparatus in which the same result is obtained in an easier and much more rapid manner. It suffices, in fact, to make the vacuum by means of a mercurial air-pump, which they have contrived. By the aid of this apparatus, one can produce a vacuum almost absolute in the tube intended for experiment, which is provided with two platina wires, placed at a distance of ·08 inches. It takes but half an hour to obtain the requisite tension. At this moment they heat the tube to redness, which must be done by means of charcoal or Bertelot's lamp, for analysis. When the vacuum is so complete that a spark will not pass, we close the communication between the tube and machine.

In a tube thus prepared, notwithstanding the exceedingly small distance between the platina points (·08 of an inch), the spark absolutely ceased to pass.

# Editorial Correspondence.

## FOREIGN SCIENCE.

Paris, *February* 2, 1868.

M. Poulain, formerly Chief Engineer of Bridges and Roadways of Gorea (Senegal), has published a very interesting description of the method employed by him for the drainage of pestilential swamps, especially with regard to the neighborhood of Hann, where vessels take in their supply of fresh water, and where remarkably rich cultivation could be carried on if one could only live there. Afterwards, he was employed on a topographical mission in Corsica, and he gave an account of the benefits that would arise from the cultivation of the soil, as well as those which would result in a sanitary point of view, in favor of the magnificent harbors that could be established in the island.

The hydraulic department of the above corps has devoted much study to all questions relating to public health and river supplies for industrial purposes. The fertility of the eastern plain of Corsica is well known to the world. Experiments, and, we may say, the history of the land, prove that when this plain is rendered healthy it will be a veritable land of promise for agriculture, &c. Several crops have been grown according to the old method, and the results have proved that the quality of the land and the nature of the climate are of a superior order, also, that the richness of the soil is due to ancient alluvia, produced by the wearing down of the mountains, mingled with the vegetable detritus of centuries. Unfortunately this part of the island is studded with swamps, so that it is fatal to remain there in summer or autumn. To this land the application of M. Poulain's system will be of immense service, in rendering the cultivation profitable in the same manner as has been shown in the Dombe, the Sologne, the Carmagne, and in the Landes of Gascony. By employing Italians, Corsicans and convicts accustomed to the climate, and with proper hygienic precautions, the necessary works can be satisfactorily executed. There is no risk to be incurred during the winter, as the prevailing winds coming from the west drive the miasma towards the sea. The water covering the surface of these swamps diminishes by the action of solar heat, winds and infiltrations, passing from winter to summer. The shores of these pools are often of such a feeble inclination, that they remain in the state of mud and produce miasma. Thus we have annually a very unwholesome surface, according to circumstances. The marshes, the bottom bed of which is wholly situated above the level of high water, can be drained by a main drain, which will prevent them from being covered with water. In default of sufficient inclination, the water would be stagnant in the canal, so that M. Poulain proposes to fill up by artificial means the deeper parts of the swamps or pools. These latter require some management; the main drain should be furnished with one or several metallic valves fitted on to a sluice opening to sea-ward, upon the pressure of a few centimetres of water. The valves serve perfectly for the flow of rain-water, even for a large surface, if the ground permits, and the sluice only fulfils the duty of hindering the canal from being silted up by sand, &c.

The ideas newly put forth by M. Poulain, consist in utilising, on a large scale, the sea for draining the shore by putting it into communication with swamps and pools, so as to renew the saline water of the marshes, and raise or lower the level so that it shall be always sensibly the same. Those whose level is constantly and entirely below that of the sea in summer, are otherwise treated, and he takes as an example the pool of Biguglia, which is very large and miasmatic; situated very near Bastia, it spreads the deadly emanations to the very town. The swamp contains 1370 hectares, to which must be added 304 hectares, making in all, 1674 hectares (4136 acres, I. R. 32·6 p). Its level varies from 0 to 5 feet above the level of low water, and its greatest depth relative to this level does not exceed 7½ feet. Thus it is plain, that the annually dangerous surface is of vast extent. The pool, 7¾ miles long, is separated from the sea by a dune of sand, very narrow, but of regular width in general, the minimum width being a little over 600 feet. It has been known for centuries as the dune or hillock, and is marked on the most ancient charts.

By canals which communicate with the swamps and the Mediterranean at each tide,* the level of the pool being entirely below the sea level in summer, the sea water introduced in proper quantity into the marshes would renew the water of the pools, and contribute towards their salubrity; the extensive annually-dangerous surface, corresponding to a depth of 5 feet below the sea level of low water, without taking into account all that is above, would be replaced by a surface of considerably reduced dimensions, corresponding to a fluctuation of a few inches only, for example, and constantly bathed with healthy water. This system, of which we give a rough sketch, leaving the calculations for the end of the chapter, would not be very expensive. It consists in simply opening across the narrow dune, narrow and shallow channels, the bottom being a little below the lower sea level, and to continue them, to protect the embouchure by small jetties, carried downwards to only a few yards below low water, as beyond the depth of two yards the sands are very rarely displaced. The dune should be well planted, in order to prevent the sands from being transported by the wind.

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* It is erroneously supposed that the level of the Mediterranean is constant and the sea tideless. It ebbs and flows, and Captain Smyth, who surveyed many of the shores, states that he found a tide, small certainly, but decided, although not governed by the moon. Admiral Fitzroy also remarked a rise and fall. Also the tidal current in the Fars of Messina is well known.

The unhealthy pools (they are not all so) and the marshes may be surrounded by a very thick and continuous belt of olive or other suitable trees, which can act as an additional barrier against the miasma. This is the system proposed by M. Poulain for draining or purifying the marshes on the eastern plain of Corsica, and it can be carried out economically by improved mechanical means, such as portable engines, excavators, &c. It is possible that these works would not exceed eight dollars an acre, which is very little, considering the great benefits resulting to the property situated in the east of Corsica. The expense will be covered by the application of the law of the 16th September, 1807, a special law which obliges the proprietors of the neighboring lands, both plain and valley, each to contribute a portion of the expense, according to the benefit received by them in a sanitary point of view. M. Poulain is of opinion that a pool or lake, situated very near the sea-shore, the level of which is constantly below that of the sea, can be rendered healthy by putting it in communication with the latter, by means of canals, so that the fluctuations of a few inches on either side of the mean level can be the result of the more considerable oscillations of the sea. The dangerous surface becoming thus constant, and of small extent, washed, besides, by renewed water, can be made to lose entirely its putrid qualities. It is therefore necessary to know, at least approximately, the width of the canals which will give fluctuations of $\frac{4}{5}$ths of an inch about, for example.

The solution of this problem is very complex on the one hand, because many of the laws of hydrodynamics are yet to be found; on the other hand, because we reach expressions under the sign $\int$ that we cannot resolve. M. Poulain furnishes us with approximate numerical solutions. He supposes that the pool is put in communication by an horizontal canal. The water of the sea will be poured into the pond, and *vice versa*, that of the pond will flow into the sea, according to the rise and fall of the latter. When the water has attained its maximum height in the pool, it will receive no more, and will be at the point of yielding it.

There will exist *at the same moment* a common level between the sea and the pool, for the highest and lowest levels of the latter.

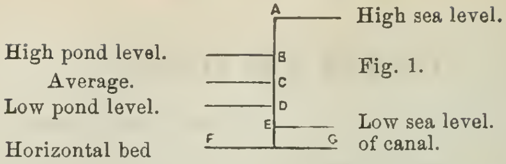

Fig. 1.

B D represents a demi-fluctuation of the pool, whether the water pours inwards or outwards, that is to say from the sea to the pool, or from the pool to the sea. The flow of water by the same horizontal canal, will be subject to the same laws, in both directions, unless we take into consideration atmospheric circumstances, which we have no reason to pay attention to here; it will be constant, but alternatively positive and negative, and consequently the horizontal lines B and D will be equidistant from A and E, which represent the high and low levels of the sea (B A = D E), or in other terms are mean levels of the ponds, and the sea will coincide.

Fig. 1 shows that the pond when at its lowest, D, will be in the process of filling when the sea rises from D to A, and falls from A to B, and that it will be on the contrary in the course of emptying, when the sea falls from B to E, and rises from E to B. It is also evident that the mean levels of the pond and the sea, which are the same, are not simultaneous.

[The learned author here plunges into an ocean of calculus, from which he emerges after a time, with the following conclusions rescued from the devouring element.—Ed.]

For a variation twice daily of two centimes of level in the pool, a canal 15 mètres wide is necessary. If we wish to renew the water in the pool in a greater proportion, several similar canals must be opened on chosen points; and then the variation of the level in the pond, instead of being two centimètres, can be increased to four or five, which would be excessive.

Also, if the bottom of the canal be paved with stones, no injurious effects would be produced by the currents. The following table is of interest in this connection.

| | | | *Per Sec.*<br>M |
|---|---|---|---|
| Wet soils begin to | be transported by | water moving at the rate of | 0 07 |
| Soft clays | " | " " | 0·15 |
| Loose sands | " | " " | 0·30 |
| Gravel | " | " " | 0·60 |
| Pebbles | " | " " | 0·61 |
| Broken flint stone | | " " | 1·22 |
| Agglomerated pebbles soft pudding stones and stratified rocks | | " " | 1·83 |
| Hard rocks | | " " | 3·65 |

F. Moigno.

# OUR NEW YORK LETTER.

NEW YORK, *January*, 1868.

SOME ten or a dozen years ago, a charter of incorporation was granted by the Legislature of this State for the formation of the "American Society of Civil Engineers." Mr. James G. Laurie (who was the first President), is entitled to the credit of its origination, and many of the most noted engineers in the country were enrolled among its members. It was the anxious desire of all to make the Society felt as a power, besides establishing a bond of fellowship and an *esprit du corps* in the profession.

Lack of funds, however, prevented the Society from establishing permanent headquarters, as was necessary, and meetings were held in the office of Alfred W. Craven, Esq., the present head of the Croton Aqueduct Department. Interest in its proceedings gradually failed from one cause and another, until finally the Society existed merely in name, and in the memory of its members. During its brief existence certain moneys accumulated, and had been invested for its benefit. Last fall, some of the old members met together, and determined to revive the old Society on a new basis, and invited the coöperation of their professional friends. The movement met with hearty approval, and thus encouraged, the accumulated funds were expended in handsomely fitting up a couple of pleasant rooms for a down town exchange, and a reorganization was immediately put in force. The first meeting was held last December, and Mr. James P. Kirkwood was elected President, with Col. Julius W. Adams as Vice, while Mr. James O. Morse, the original Secretary of the old organization, was still kept in office.

At this meeting the President delivered a most excellent and practical address, going over the ground of the past difficulties of the Society, and pointing out wherein he conceived the element of success lay. He dwelt especially upon the importance of professional papers and communications, as being essential to keeping up an interest and life among its members. Such papers should be printed and distributed among all non-resident members, who should feel obliged to send on their experiences and observations, be they small or great, for the edification of their resident brethren. It was an address replete with sound and honest advice, and was heartily responded to by the members present. The Committee on papers and printing have printed this address in connection with a short circular, urging all members to take hand and make the Society in reality what it aims to be—the exponent of the engineering profession in America—and to hold the same rank and position as the English Institution of Civil Engineers, or the similar organization of France. Judging from the spirit that now actuates the members, little fear, I think, may be had of the future; and we hope to do much towards educating the public in the idea that engineering is not a trade, but a learned profession, practised by gentlemen. At the January meeting, a full attendance showed the interest felt; and a valuable paper was read by Mr. Craven on the breakage of some of the enormous ten feet mains of the Croton Aqueduct. A communication was read by the Secretary, Mr. Morse, from Mr. McAlpine, upon the subject of corrosion of cast iron immersed in sea water. After citing numerous experiences of his own and others, he is of the opinion that cast iron piles are not subject to any corrosion whatever, if the ore from which the iron is made is properly selected. *Soft* cast-iron will rot and become spongy, turning into a graphitic substance; but *hard* grey iron castings have never been known to fail by corrosion. Most of the members feel now that the Society has fairly been launched on a successful career, and may God speed its mission. Many of the oldest and most experienced engineers in different parts of the country have signified their willingness to take hold and put their shoulders to the wheel, and to give it such assistance as may lay in their power.

The meetings are held, at present, at one o'clock, P. M., as the location of the rooms in William street is in the strictly business portions of the city, and were so chosen, as well as the hour, in order that no excuse could be had for non-attendance of the members. If for no other reason it is agreeable to think that our own migratory profession has a head-quarters in this the commercial centre of the country, where they can meet their brethren, fight their battles over, and extend their acquaintance. As long as New York is the great centre of capital, so long will engineers be drawn hither in the development of their schemes and projects, more than to any other point. How important it is for them that the American Institute of Engineers should be a success. The time is coming, too, when New York will have her Great George street, where engineer and contractor will be sought for, when professional employment will come seeking them, and not they the employment. The day is not far distant when capitalists will call in the aid of the professional engineer instead of the "practical" man who has heretofore been depended upon, and when the scientific engineer will cease to be ignored, as merely a "paper" and "book" engineer, which the public find very hard to harmonize with their notions of a "practical" man.

The fearful rigor of the winter has put a stop to public improvements, although many are on the tapis. The elevated railroad is not as yet running, being unexpectedly delayed. From present appearances, it will be a month yet before things are in such a shape as to test the practicability of Mr. Harvey's scheme. A perfect inundation of bills for the "relief" of New York are pressed upon the Legislature now in session. Everything tends to the underground this year, and, if carried out, would honey-comb this unfortunate city from one end to the other, and expend, in so doing, the amounts of several national debts. One of the schemes embodies what the *Tribune* facetiously calls a pop-gun under the East River from this city to Brooklyn, through which passengers, &c., may be blown back and forth by compressed air, in no time whatever. I have not heard the time estimated that it will take to blow a passenger from the Battery to Washington Heights, but I think that it is somewhere in the neighborhood of three seconds —perhaps not so much. The "Nolan" project to excavate Broadway from building to building, and have an arcade with stores, besides innumerable freight and passenger roads run with gas-consuming "dummies," is strongly pressed this winter at Albany. The little difficulties of sewers, gas pipes, water mains, &c., to be met by pipes, supported on columns, and the street level is made by paving on huge iron girders, supported on plates and columns. The iron men think this a grand scheme, and certainly ought to be instituted. The people who own property think that *perhaps* their stores might tumble down when they were undermined; but, pshaw! that's nothing these days, when we reflect upon the company that proposes to tunnel the Atlantic, disgusted with the long ten days that it takes to cross that ocean. The East River Bridge has progressed no farther than the borings, and perhaps the Union Ferry Company don't purpose that it shall. The Brooklyn Councils will be asked, shortly, to subscribe three millions to the stock of the Company, inasmuch as they have not succeeded in having it taken by outsiders. Col. Adams has published a severe criticism of Mr. Roebling's plan, which is caustic, if not altogether just.

The Hudson Highland Suspension Bridge Company is applying for a charter to build a bridge over the Hudson from Verplancks to Buttermilk Falls; the capital (two and and a half millions), with power to increase. It is one of the schemes of struggling Bostonians to get a little direct western trade, especially coal, without breaking bulk. The railroad companies are expected to subscribe largely, especially poor bleeding "Erie," who don't see it, and cannot understand why she should cut off her New York terminus to please Boston. Turner's, in Orange county, would be the point at which trains would leave the Erie road. As the roads that would use it are not yet built, this bridge may be regarded as also in the future. It takes New York to get up big schemes of all kinds, characters and descriptions.

The N. Y. & N. H. R. R. will put on, this week, compartment cars for their Boston through travel, which will be a great comfort for our aristocratic Americans who do not like to travel in the usual democratic manner, with everybody and anybody.

I noticed, at Van Nostrand's, the other day, a new and revised edition of Barlow's Strength of Materials, brought up to date by Mr. Humber. It is a work full of observed facts, and one that every engineer ought to have by his side in designing constructions. In an appendix the effect of "gradients," as also the effect of "moving loads on rails," is most admirably and judiciously discussed to a greater extent, and with more practical results, than in any other book I have seen.

Van Nostrand, who is sole American agent for Colburn's "Engineering," tells me, for a scientific periodical, that it has a most extraordinary circulation, and is constantly increasing. I know of no professional journal so worthy of success, and its weekly visit one learns to look forward to. It is a marvel of cheapness, too, and is conducted with an energy and zeal that insures a success. Its superb paper and print, with its unsurpassed engravings illustrating every new thing under the sun, are features that make this journal a real pleasure to read. A. P. B.

# Civil and Mechanical Engineering.

## RUTHVEN'S HYDRAULIC PROPELLER.

By Isaac Newton, C.E.

No project for the improvement of steam navigation, so far as regards the propelling instrument, since the screw propeller was made a practical reality by the distinguished engineer, Ericcson, some thirty years ago, has attracted more attention than Mr. Ruthven's water-jet, as applied in the British naval vessel *Waterwitch*, and also in one or two smaller vessels.

For upwards of a year the English press, both secular and scientific, has devoted a large portion of its columns to accounts and discussions of the relative advantages and the efficiency of this contrivance. These discussions have given to the Hydraulic Propeller an importance in the eyes of nearly all who have read them, with the exception, perhaps, of a few professionals, which an analysis of its construction and an examination of its performance will show is far beyond that to which it is entitled on the grounds of its merits. The apparent simplicity of this method of propulsion—the propelling instrument being concealed, as will presently be shown, in a box within the vessel—has doubtless caused by far the greater number of those who have witnessed the trials with the *Waterwitch*, to entertain erroneous views with respect to the efficiency and capabilities of this apparatus. Admiral Farragut, in a report to the Navy Department, on the occasion of a short trip which he made in this vessel, on the invitation of the Admiralty, says:—"So soon as we got on board we proceeded out of the harbor, and, to my amazement, she went ahead at a speed of seven or eight miles per hour, against a fresh breeze and quite a 'sea.'" If the gallant Admiral had reflected on the disproportionate expenditure of steam-power which was necessary to achieve that speed, he would have seen that the same power applied to an ordinary propeller would have given a very much higher velocity to the vessel; and could he have taken a peep at the propelling instrument, which is concealed in a huge cast iron box, he would have been amazed to find, that while the *Waterwitch* is but about one-fifth of the size of his flag-ship, the *Franklin*, her hydraulic propeller is heavier and more bulky than the simple screw of the heavy frigate. In order to make the principles and peculiarities of the hydraulic propeller intelligible to those readers who have not given attention to the subject, as well as to render the description, which will presently be given, of the machinery of the *Waterwitch* more easily comprehensible, we will give a brief elementary explanation of its mode of action. Propulsive force is applied to the vessel simply by the discharge of a column of water from two nozzles—one placed on each side of the vessel above or near the water-line—and pointed directly opposite to the direction in which it is desired to drive the ship. The force which propels the vessel ahead is produced in precisely the same way as that which causes the arms of that familiar philosophical toy known as Barker'a mill, to revolve; that is, by the reacting pressure which is produced by a fluid flowing out of an orifice; this pressure will, of course, vary as the square of the velocity of the flow. The familiar example of a rocket will make this still more clear. A rocket, as is well known, is forced through the air by the continuous pressure produced by a stream of gas rushing out of the body of the rocket in a direction directly opposite to that in which it is driven. Substitute a stream of water for the stream of gas, and let it flow with the velocity necessary to give the same pressure that is created by the gas, and the result, as regards the propulsion of the rocket, will be the same. And, on the other hand, if it were possible to cause a stream of gas to issue from the stern of the ship, sufficient to produce the same pressure in relation to the resistance, as is the case with the rocket, the vessel would be propelled ahead with equal velocity. Now that the principle of the hydraulic propeller is understood, we will proceed to give a description of its application to the *Waterwitch*, as brief as is consistent with clearness, as well as the dimensions of that vessel, and then make a comparison between this instrument and the ordinary screw propeller, in order that their relative merits and comparative efficiency may be plainly set forth. This we are able to do accurately, as working drawings of this machinery are lying before us.

The *Waterwitch* is 162 feet in length between perpendiculars, by 32 feet breadth of beam and 13 feet 9 inches depth of hold; her average draft of water is about 11 feet. She is rather flat-bottomed, and is built double-ended, with a rudder at each end. We now come to the propelling machinery. Nearly midway, in a fore and aft direction, and in a precisely central position transversely, on the bottom of the vessel, a long shallow box of iron is riveted; this box extends seven feet on each side of the keel, and for a distance of about twenty-two feet in the direction of the length of the vessel. The lower side of this box (or rather the bottom of vessel which forms its bottom), is pierced with a great number of small rectangular orifices, which give admission to the water on the outside of the vessel; there is a partition in the box which divides the part which communicates with the sea from the other portion which has no such communication: this partition is fitted with sluice valves, so that the water may be shut off or regulated from one portion of this box. On top of the latter portion of this box the hydraulic propeller or centrifugal pump is placed with its axis vertical. This pump, or rather wheel, is circular; it is 14 feet 6 inches in diameter, and weighs no less than 8 tons. It is constructed of two boiler-plate disks, curved somewhat like a saucer, and placed about 2 feet 3 inches apart; these disks are secured to a cast iron centre, which is in turn attached to the shaft of the engines, by means of which it is revolved. Between these disks, and riveted to them, are placed twelve arms or blades, thus dividing the space between the disks into twelve spaces one end of which communicates with the water-box already described, by means of a circular hole 6 feet in diameter, cut in the lower disk, and the other end terminates at the circumference of this wheel, or, more properly, centrifugal pump. The blades or arms are curved in a peculiar manner, which it is not necessary to describe for a clear understanding of the subject. Surrounding and enclosing this centrifugal pump, and bolted to the water-box already mentioned, is a cast iron circular case, in which it revolves; this case is 19 feet in diameter, and it is made with great care, being accurately *turned* and polished throughout its interior surface; the object being to reduce the friction of the water forced against it by the pump to the lowest possible point. Leading from this case, in opposite directions, are two rectangular-shaped discharge-pipes, made of copper, and curved so as to reduce the friction of the water. These discharge pipes lead to the nozzle-pipes, which are attached to the exterior of the ship's side, at or about the water-line—the discharge-pipes within the vessel are 2 feet 1 inch by 2 feet 3 inches, and the propulsion nozzles on ship's side are 24 inches by 18 inches; and they are continued 8 feet in a fore and aft direction each side of the centre. These nozzles are two in number on each side of the vessel, one pointing forward and the other aft; by means of valves in the discharge-pipes, which can be operated from the deck, the stream of water can be projected aft or forward, thus changing the direction or turning the vessel at will. On the top of the circular pump case, and rising far above the water-line, are placed the steam-engines for driving the centrifugal pump. They are three in number, and are connected directly to the shaft of the pump on one crank-pin, at an angle of 120 degrees with each other. Their cylinders are 38½ inches in diameter, by 3 feet 6 inches stroke of piston.

The whole of the machinery is elegantly proportioned, and the workmanship is as fine as it is possible to make it. The centrifugal pump or hydraulic propeller "and its casing and copper propulsion pipes are all marvels of workmanship." The machinery, exclusive of the boilers—*i. e.* the propeller, its engines and pipes—occupy 29 feet of the length of the vessel, by the full interior width, and in height 13 feet from the bottom of the vessel; in a word, 10,556 cubic feet is required for the propelling machinery. It will now be proper to devote a few words in explanation of the mode of action of this contrivance. The sluice valves which separate that portion of the box (attached to the bottom of the vessel) which is open to the sea from that portion which opens into the six feet-diameter circular hole in lower disk of the pump being opened, the water enters and fills the spaces between the radial arms or blades which have already been described. The centrifugal pump is now made to revolve by means of the steam-engines attached to its axis, and the water contained within the spaces is driven out by centrifugal force into the cast iron case, and passes from it, by means of the pipes, to the propulsion nozzles which are attached to each side of the vessel. The velocity and quantity of the water thus projected, in a direction contrary to the motion of the vessel, is, of course, governed by the perfection of the apparatus; and in this respect the performance of this particular design seems to reach the maximum possible, being, as it is, the result of the experience of some thirty or forty years of experiment and mathematical investigation; in a word, no greater increase in the ratio, between the useful effect and power applied to a centrifugal pump, than is in this case achieved, seems to be possible.

Now that the construction, arrangement, and mode of action of the centrifugal pump, employed as a propelling instrument for steam vessels, have been explained, it would seem that a comparison between it and the screw propeller, is properly the next step in this investigation. And this, because in bringing out the points of difference and the advantages claimed for the one instrument over the other, the probability of the introduction of the hydraulic propeller will be readily seen.

Let us, in the first place, compare these two propellers, under the assumption that they both possess equal propelling efficiency—that is, that each of them transmits the same proportion of the power used in driving them, to the propulsion of the vessel. In the next place, we will glance at their relative efficiency as instruments to transmit the power of the engine to force the vessel through the water. With respect to the first comparison: The screw propeller, it is almost unnecessary to state, consists of a central hub, with (usually) four helical blades attached to it. This propeller is fastened to a shaft which—if a single propeller is used—projects through the stern-post beneath the water-line. Such an instrument as this, to properly transmit the power developed by the engines which drive the centrifugal pump of the *Waterwitch* (viz: from 7 to 800 horse-power) would require to be about twelve feet in diameter, and would weigh only about four tons, and engines to drive this propeller, of a sufficient size to work up to 800 horse-power at a moderate speed and a moderate pressure of steam, would not occupy more than 1350 cubic feet in the vessel—that is, 150 square feet on the bottom of the ship by 9 feet in height. Now, contrast this with the enormous space required within the vessel by a hydraulic propeller and its engines (the *Waterwitch*) necessary for the utilization of the same power—that is, 29 feet in length by 28 feet in width by 13 feet in height—10,556 cubic feet, or nearly eight times as much as would be necessary with a screw.

And when we contrast the enormous space—29 feet in length by 28 feet in width by 13 feet in height—10,556 cubic feet—required within the vessel by the hydraulic propeller and its engines for the development and application of the same power as that required by the ordinary direct-acting screw engine attached to a propeller placed *without* the vessel, and consequently occupying no room within, it would seem to be a formidable point against the hydraulic method. For instance: If, as is the case with the beautifully designed machinery of the *Waterwitch*, upward of 10,000 feet cubic are required to apply and utilize but 771 horse-power, it would require upward of 83,000 cubic feet (that is 60 feet of the middle and best part of the vessel by 48 in width, and by the whole depth from the floor to the main deck) to apply and utilize the 6400 horse-power given by the engines of the English ship *Bellerophon*, which only occupy 29 feet in length by 30 in width by 13 in height, from the floor, or 11,310 cubic feet, which is but a trifle more than that occupied by the 771 horse-power contrivance in the *Waterwitch.* It seems, therefore, almost unnecessary to remark, that on this ground alone, it is quite impossible to apply the hydraulic propeller to a first-class ship of fair speed. And we may here remark, recapitulating somewhat, that, from the foregoing, it appears to be evident, that the hydraulic motor cannot be economically employed in freighting and passenger vessels, even of medium steam-power, on the grounds of the great weight and space required for its use, and its consequent cost, as well, also, as its inferiority as a propelling instrument, as compared with the propellers now in use.

Again, let us look at the relative weights of engine and propeller required for the two methods of propulsion, bearing in mind, as we have done before, that we have assumed both systems to be of equal efficiency as propellers, and the problem is to apply and transmit equal power—in this case 771 horse. We have stated that a screw, to properly use 771 horse-power, would require to be about 12 feet in diameter, and would weigh about four tons; and a direct-acting screw engine, to develop this power at moderate speed, and with a moderate pressure of steam, would weigh, as ample experience proves, some 40 tons; hence the engines and propelling apparatus, collectively, necessary for the screw system, would weigh not over, say, 50 tons.

As to the engines which drive the centrifugal pump of the *Waterwitch*, it is not safe to place them at less than 45 tons; the centrifugal pump itself weighs 8 tons, and the 19 feet diameter casing of cast iron which surrounds it, together with the water-boxes, sluice-valves, propelling nozzles, &c., must weigh at least 50 tons more, and to this must be added the weight of the water required to fill the enormous casing, the propulsion pipes, water-boxes, &c. (and they must be filled when it is in operation), and this is certainly 40 tons more. Here, then, we have an aggregate of no less than 143 tons required for the hydraulic propeller, against 50 tons required for the screw propeller; this would seem to be another point against the former.

Now that attention has been directed to the above features, it is proper to state those points which the advocates of the hydraulic propeller claim mark its superiority over the screw. A number of these claims for superiority are for the use of the hydraulic motor in vessels of war, but they will be seen so readily that they need not be specially pointed out.

1. That the propeller being wholly within the vessel, the risks from shot or fouling are avoided. As the screw propeller is usually wholly beneath the water-line, it is almost impossible to injure it by shot, and if one of the blades, which sometimes project a short distance out of water, should be hit, it would only injure it by breaking a piece off its end, not a very serious matter. There is no case on record of a screw propeller being injured by shot. Instances of screw propellers fouling are now very rare, and that without any appliances to prevent it. No vessels have been exposed to more danger of fouling their screws than were the monitors in Charleston Harbor and elsewhere; yet in no case were their screws fouled, notwithstanding the endeavors made by the enemy to disable them in this way; this is doubtless due to the application of one of those small but important inventions which necessity sometimes brings out; this extremely simple anti-fouling contrivance of the monitor can be applied to any screw vessel at trifling cost, where such precaution is deemed necessary, which is not the case with vessels of peace. On the other hand, the use of the hydraulic propeller renders the propelling power much more liable to be disabled by shot than is the case with the screw. And this for the reason that at or above the water-line (*Waterwitch*) there is on each side a propelling nozzle 16 feet long, with a discharge orifice in each end 24 inches by 18 inches. Although these big boxes sticking out on each side of the ship may be covered by heavy armor-plates, artillerists know that a shot from a modern gun would break them in and utterly destroy the propelling power of the vessel; if the attempt is made to make these excressences invulnerable by the employment of thick backing, heavy ribs and very thick armor, they will at once assume such cumbrous proportions as to put this plan out of the question.

2. The next great claim is the superior manœuvring power which the hydraulic propeller gives to the vessel. This manœuvring or turning power is accomplished by directing the discharge from one nozzle astern, and the other ahead. On this point a high authority says:—"The hydraulic vessel (the *Waterwitch*), discharging her water ahead from one nozzle, and astern from the other, took about twice as long to turn as the double screw vessel (like our monitors of the *Monadnock* class), viz: about 6½ minutes as compared with 3¼."

But with either the double screw or the hydraulic, experiments prove that the manœuvring power is much less than is generally supposed, and that because the turning power acts at so short a distance from the centre of gravity of the vessel.

3. That with the hydraulic propeller the vessel can be reversed without reversing the engines, and that this operation can be performed by an officer on the deck. The reversing is effected by moving two enormous valves in the propulsion pipes; if these valves get out of order, not only is the power of reversing destroyed, but also the propeller itself—a disadvantage which engineers will not admit is compensated for by the suppression of the extremely simple reversing gear usually attached to the engines. If it is desired that the officer of the deck should operate the engines from the deck, it can be very easily accomplished by leading-rods from the engine to the deck. There has been a double-screw tug-boat running in New York Harbor for many years, where the throttle-value and reversing handles are in the pilot-house, and the officer of the deck steers, stops, starts, backs, or turns his boat without moving from a high stool. Can the hydraulic propeller do more?

4. That the hydraulic will be less affected by the motion of the vessel in a sea-way than the screw. Quite the contrary; rolling, while it does not affect the action of the screw materially, would operate seriously against the action of the propelling power of the water issuing from nozzles alternately depressed many feet into the sea, and raised equally high out of water. And as for pitching, the screw engine is now as accurately controlled by the governor as an engine in a cotton mill. There are other points claimed, but they are of no consequence, besides want of space warns us that we must bring this account of the water motor to a close.

And we will therefore speak of the last comparison we now intend to institute between the hydraulic propeller and the screw propeller, and that is their relative efficiency as propelling instruments. By efficiency is meant the ratio between the power applied by the engine to the propeller and the power utilized in urging the vessel through the water; the difference between the power developed and power so applied is, of course, wasted in doing work which accomplishes nothing towards driving the vessel.

In order to make this comparison perfectly clear, it is only necessary in the first place to quote the results from the official trials of the *Waterwitch*, and compare the power which is required to propel her at a certain speed with that which is necessary to propel freighting propellers of similar model in this country at the same speed. To begin with, we find from the official dimensions given of the *Waterwitch*, that her model is better than that of our freight propellers on the North River and Long Island Sound. Those familiar with the subject will understand this when we state that between 35 to 40 per cent. in her model is cut away from the solid, represented by her length, breadth and mean draft; which shows pretty conclusively that her model is even better than that of our propellers with which we wish to compare her. Now, referring to the official accounts of the trials of the *Waterwitch*, the following is the result:—Immersed mid-section, 347 square feet; horse-power, 777; speed, 9·2 knots—that is, by the usual calculation, 2·8 horse-power are required for each square foot of immersed mid-section to give a speed of 10 knots; and very extensive experience with our bluff freighting propellers shows that but 1·8 horse-power per square foot of immersed section is necessary for the speed of 10 knots. Hence, it is evident that the hydraulic propeller in the *Waterwitch* is, as a propelling instrument, 36 per cent. less efficient than the ordinary screw propeller; or, in other words, it wastes 36 p. c. more power than that method of propulsion. Why there should be more loss with the hydraulic than with the screw, it is quite easy to show mathematically; but we may rest contented here with having demonstrated the fact, without giving the reasons of their sources of loss. As respects the merits of the two systems, we may say, in recapitulation, that it has been proved that, even provided the two systems possessed equal propelling efficiency, that the screw possesses very marked advantages over its rival; but as it has also been established that the screw far exceeds the hydraulic in propelling efficiency, the conclusion that the hydraulic method cannot compete with the screw propeller, it would seem cannot be gainsaid. One more comparison, and we will tire the patience of the reader no longer. In the year 1837, the British Admiralty were towed ten miles an hour on the Thames by a screw propeller. They shook their heads at the scheme, and pitied the inventor for his sanguine credulity; the same propeller, with almost identically the same proportions, is the motor of all the navies of the world, and has now almost driven the paddle wheel from the ocean. In 1867 the British Admiralty make sundry excursions with the hydraulic propeller, and are infatuated with its merits and this contagion of enthusiasm seizes the English press, and an ancient motor, promulgated as long ago as 1661, receives as much attention as though a new era had been commenced in naval warfare by its resurrection.

# THE SUPPORTING POWER OF PILES, BOTH OF WOOD AND IRON, AND THE USE OF THE LATTER, EITHER AS PILES OR COLUMNS OF SUPPORT FOR FOUNDATIONS.

A PAPER READ AT THE FRANKLIN INSTITUTE, JANUARY 15, 1868, BY HON. W. J. McALPINE, LATE STATE ENGINEER OF NEW YORK, ENGINEER IN CHIEF OF THE U.S. DRY-DOCK AT BROOKLYN, MEMBER OF THE INSTITUTION OF CIVIL ENGINEERS OF LONDON, MEMBER OF THE FR. INST., &c.

(Continued from page 110.)

If the sand is free from logs and stone, then small piles may be used, say of one foot diameter, with expanded iron bases.

Assuming that the weight of the pier, superstructure and load, is fifteen hundred tons, and that such piles are driven to a depth of sixty feet below low water, with a scour of thirty feet, the external frictional surface of the remainder of the pile and the area of the base, will afford a sustaining power which will require about thirty piles to carry the load with safety, and with the grillage on top, ready to commence the masonry of the pier at low water, will cost about thirty thousand dollars ($30,000.)

If logs or stone are encountered, the iron columns must be enlarged sufficiently to allow the workmen to descend them, and remove or cut away the obstruction.

The least diameter which will permit of this descent is thirty inches, and in this case there must also be provided a working chamber at the bottom, of probably five feet diameter.

This chamber can be made by a conical instead of cylindrical pipe at the bottom, which must be made thicker than the other parts of the column, as a greater part of the load will be carried by it, with a strain partly across the shell. It may, at first, be supposed that the column with this shaped bottom, will be more difficult to drive, but it will be seen that with any process of interior excavation, the column in this shape will descend with even more facility than if cylindrical.

In addition to the increased bottom support which this expanded base of iron will give, the concrete filling may be extended below the bottom of the column from four to six feet, and also beyond its external lines from two to three feet, thus giving a further expansion of the base, equal to eight feet or more in diameter.

Nine such columns will bear the assumed load with safety, and with the grillage, ready for the masonry, will also cost about thirty thousand dollars ($30,000.)

A pier, wholly of iron, may be made, and would consist of two columns of eight feet diameter and one hundred feet long.

They would require to be cross braced with iron, and a starling made either of iron or wood. I prefer the latter, and would propose to make it by sinking two small columns or piles, of fifty feet length, at the upper extremity of the pier, to sustain a level floor: the lower end of which would be supported on flanges on the main column.

Upon this floor an ice-breaker, in the ordinary form, of wood, well packed in with stone, would be built.

If desired, this timber work could be carried around the columns, and form a protection or guard to the braces.

Timber, under such circumstances, would last ten years, and would not cost $1000 in its renewal.

I have stated my preference in favor of a wooden starling, and this is because it has considerable elasticity, which will take up some of the momentum of the blows of heavy bodies striking the pier, and will save the iron from shocks.

Such a pier, with its braces, starling and capping complete for the superstructure, would cost about forty thousand dollars ($40,000.)

The comparative cost of a stone pier resting on wooden piles, under the same circumstances, would be, approximately, as follows.

Assuming that the mean depth of the water at all of the piers was ten feet below low water, to found the pier at twenty feet below would require ten feet depth of dredging, and to prevent the sand from flowing in would require a curb of ten feet height.

To obtain a penetration of thirty feet with the piles, and to permit them to be driven from above the ordinary stages of the water, would require timbers about sixty feet length. When these were driven and cut off at the proper level, the masonry could be built in a caisson and lowered upon the piles.

Under the assumption that the scour of river will reach to a depth of thirty feet, there will be but twenty feet length of these piles to sustain the load. The load will also be increased to two thousand tons by the extra masonry between the foundation and low water, and will require more than two hundred piles to sustain it.

The cost of such a pier, brought up to the level of low water, would be thirty-six thousand dollars ($36,000), and forty feet higher, viz: to the bridge seat, would be forty-five thousand dollars. ($45,000).

The case which has been assumed, is one of those which shows most unfavorably against the use of wooden piles; but is by no means a rare one on the western rivers. It, however, serves to show that, under difficult circumstances, the use of iron piles becomes actually cheaper than wooden ones.

There are many cases, however, when the latter will be the least expensive, and also when the more important question of the safety of the piers and structure is involved, and my chief object is to call your attention to this feature.

From what has been said, it will be observed that the iron piles and columns derive the largest portion of their support far below any possible action of the river currents, and therefore, that they may be relied upon for safely carrying the structure under the most unfavorable circumstances.*

If an ice or drift gorge should scour out the sand about the piers to a depth of forty or even fifty feet, the pier and structure would not be endangered.

It is true that these columns, standing like stilts, forty or fifty feet high, would be objectionable if left so for a considerable time; but no immediate injury would ensue, and when the space around them was filled up with stone, as it would be at the earliest convenient time, the piers would forever after be safe against any future scour.

The first use of this system was a process patented in England, by Dr. Potts, to found a lighthouse on Goodwin Sands.

It consisted in exhausting the air from the hollow iron pile, and then the pressure of the atmosphere, the weight of the pile, and sometimes that of an added load, caused it to penetrate into the sand.

The bridges at Rochester and Peterboro', and some others in England, as well as those in this country, were all commenced upon that plan; but, while it answered very well for small piles in a sandy bottom, it was found inefficient with large piles, and of no value when they encountered, in their descent, logs, stone, or even a compact material.

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*In arranging the plans of the foundations with iron piles, for the purpose of making the above comparisons of cost, it so happened that a greater number of columns were drawn in the plan than was necessary to carry the load, so that the estimates cover the cost of a much larger sustaining power than was provided for in the case of the wooden piles. If any exception should be taken to the estimated cost of the latter, it may be answered that corresponding reductions may be made in the former. The object of the comparison, however, is merely to demonstrate that foundations with iron piles may be used at a moderate cost.

Messrs. Cubitt and Hughes, the Engineers of the Rochester Bridge, in 1849, and Messrs. Gwynne and Fleming, the Engineers of the Pedee Bridge, a year later, changed the process from the vacuum to a plenum; that is, they expelled the water out of the column by forcing in it air, condensed to the same pressure as that of the surrounding water, and the workmen excavated the material from within the column. The entrance of the men and the outlet of the material excavated, was made through a chamber on top, provided with valves in the top and bottom.

Various other improvements were made in the process, which will be spoken of in another place in this paper.

A synopsis of the European practice of this system, embraces as follows:—

1. Columns of cast iron, from seven inches to twenty feet in diameter, the metal of the small ones being half an inch thick, and of the large ones, one and a half inches, driven by the vacuum and plenum process, by the hydrostatic process, or by manual and machine excavation. These columns have been driven from seven to seventy-five feet into the sand below low water. They have generally been filled with concrete, on which the superstructure is carried; but in some cases it rests upon the iron shell. These columns are generally carried up to the superstructure, forming piers entirely of iron.

2. Columns or caissons of wrought iron, of cylindrical and other curved forms, and of rectangular ones, the metal from one-eighth of an inch to half an inch thick, driven by the pneumatic process, or sunk by the aid of heavy weights to moderate depths into the earth, the excavation being effected by manual and machine work. In these cases the caisson is filled with solid masonry, forming a base of the usual form for stone piers. In India, columns of brick are used, shod with iron or wood.

For the St. Louis Bridge a plan was submitted last summer, of a timber caisson-bell sufficiently large to build a pier 100 feet long and thirty feet wide, to be placed in a dredged pit 30 feet below low water, with its top extending to 20 feet above water. The lower portion was an inverted caisson, composed of 12 compartments, each of which were 16 feet square and 12 feet high. The upper portion was a direct caisson of the usual form, the sides of which were arranged to be removed after the masonry was completed; the lower caisson and its roof was to be left in permanently.

I arranged plans for a similar inverted caisson, in wrought iron and in compartments, for the straight piers of the Harlem Bridge.

The description of this caisson is given merely to indicate one direction to the modification of the principle.

Cylindrical columns of plank, or rectangular ones of timber, and plank shod with iron, could occasionally be used. In that case, however, the filling must be of a material which will support the structure in the event of the decay or removal of the wooden shell.

Various processes for driving these columns have been used. The vacuum and plenum pneumatic processes have already been spoken of, and the latter will now be more particularly described as I employed it at Harlem.

The pile consists of a number of hollow cast iron cylinders, A A,* six feet in diameter, 1¼ inches in thickness and nine feet in length, provided with flanges on the inside, by which they are bolted together, one on the top of the other, until the desired length is obtained. The lower cylinder is chamfered at the lower edge down to about a quarter inch thickness. From a platform, on temporary wooden piles or large scow boats, a derrick is placed, which suspends the column and lands it with the sharp end on the bottom of the river in the place where it is to be driven. Another cylinder, B, called the air-lock, is placed on top of the column, usually made of boiler iron sides, of the same diameter as the columns, with a top and bottom plate of cast iron, in which are man-holes, C C, that can be closed at pleasure by plates, D D, with hinges opening on the lower sides, and lined with rubber at the joints. In the top and in the diaphragm or lower plate, are cocks, E E, usually two inches in diameter. Leading from the outside of the air-lock near its bottom, are two curved tubes, F, four inches in diameter, which also pass through the diaphragm and are closed by cocks. The air-lock is bolted to the top of the column. Small air-pumps, usually worked by a small steam-engine, are connected with one of the curved pipes in the air-lock, by means of a flexible four-inch tube. The lower man-hole plate is then closed, and air is forced into the column.

With the first stroke of the air-pumps the operation of compressing the air commences, and as this pressure increases, it forces the water out through the open bottom. This continues until the pressure of air equals that due to the head of water outside the column, and the water has all been forced outside. The workmen then enter the air-lock, and, closing the upper man-hole, a cock is opened in the lower diaphragm, and the compressed air from below is admitted. When the pressure has become equalized, the lower man-hole plate falls, and the workmen can pass down on ladders to the bed of the river to excavate the material, which is raised in canvass bags to the air-lock, by means of a drum, G, the shaft, H, of which passes through stuffing boxes to the outside, where it is worked by hand, on signal. When the column has been entirely cleared down to the bottom, care is taken to see that no obstructions, such as boulders, logs, etc., remain under the rim of the column, and the workmen ascend into the air-lock, and, closing the lower valve, the compressed air in the air lock is allowed to escape through a cock in the upper plate. When the air in the air-lock has become equalized with the atmosphere, the upper valve falls, the men pass out and the bags of material are removed. Men are then stationed at the guy ropes and the four-inch cock in the curved pipe is opened, and the compressed air in the column allowed to escape quickly.

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* See plate facing page 98.

The upward pressure of the air in the column, on a surface six feet in diameter, neutralizes the weight to an extent which is governed by the depth of the bottom of the column below the surface of water. By allowing the air to escape quickly, in the manner mentioned, this weight is suddenly restored, with an effect similar to a blow, while, at the same time, the rapid inrush of water at the bottom, causes a complete scouring of the material at and under the sharp rim of the column, and the resistance to driving the column is simultaneously removed.

The friction of the outside of the column against the material through which it penetrates, is greatly diminished by the current of water passing along its surface from the river, on its way downward to the inside. If no rocks, trees, or similar obstructions are encountered, the column will continue to settle quite rapidly during the time the air is escaping, and afterwards, until the material has stopped scouring under the edges, and has compacted itself under the pressure of water sufficiently hard to sustain its weight. The amount of settling in one operation will frequently amount to ten or twelve feet, or even more.

When boulders or logs are met with, the column stops, and it is then recharged with air. The workmen descend and remove the obstruction, and the process already described, is repeated. In this manner columns of the largest dimensions may be sunk to depths of a hundred feet, or perhaps still deeper.

The question has been raised, whether life can be supported at such great depths, and many of the English engineers speak of the ill effect upon the health of their workmen; but this is contrary to my own experience and that of my brother, C. C. McAlpine, who entered the columns daily and remained there for several hours at a time, while conducting some of the more important and delicate operations required. The greatest depth at which we have been under water was over fifty feet. The pressure due to this depth was about 22 pounds to the square inch over the atmospheric pressure; or, with the latter added, 37 pounds; but this again was frequently increased by the extra pressure required to drive out the water through the compacted material around the outside of the column, so that the pressure was often increased by as much as an additional atmosphere, or about 52 pounds per square inch in all, equal to a depth of about eighty-five feet below the surface of the water.

After entering the air-lock it was closed against the atmosphere, and the pressure equalized with that in the column, in the manner that has been already described; and this operation, and the other one of equalizing with the atmosphere when passing out of the column, were the only times when difficulty on the part of the workmen was experienced. Men of certain kinds of constitution sometimes suffered greatly; the blood starting from the nose, ears and mouth, and the pain of changing pressure being almost insupportable upon the eye-balls and drum of the ear. These men were usually of a very nervous temperament, and excitement would induce them to keep their nerves under great strain, which added to their difficulties. No trouble was experienced in procuring men, however, who could bear the pressure perfectly well without injury. A little practice and familiarity soon accustomed them to the circumstances. The muscular action of swallowing would always relieve the ear drum, temporarily, from pain and pressure; but, after a little practice, even this was found to be seldom necessary. With new men the pressure would be let on gradually; but those more accustomed to it did not hesitate to equalize as fast as their means of doing so allowed, or in a space of less than a minute.*

The pressure once fully on, it would be difficult, from any bodily sensations, to determine a difference of pressure amounting to at least one atmosphere. The effect, while under pressure, is to cause a feeling of exhileration, so sensibly felt by the workmen that a lazy man becomes industrious, and there is seldom occasion to urge any of them in their work. The ventilation is of course, excellent, and the operation of breathing becomes so easy, that the inhalations are slower and shorter than in the usual atmosphere.

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* This effect is the same as that produced in a diving-bell, but is much less intense.

Upon leaving the column and again entering the ordinary atmosphere, the absence of the stimulus of so much oxygen produces a certain degree of lassitude for a time, unaccompanied, however. with any other difficulty. It could not be observed, either in our case or that of the workmen, that in an experience extending over a year, any effect prejudicial to the health or constitution was produced.

I have already alluded to the extension of the concrete filling below the bottom of the column, and to its lateral expansion beyond its vertical lines. I believe that this has not been used in any similar work, and as it so much increases the supporting power of the column at its greatest depth, and at so small an expense, I have thought that a more particular description of the method adopted by me would be interesting, particularly as it has been questioned by those who have not tried it, whether this extension and expansion was practicable in all situations.

I will first call your attention to the increased support which this expanded base furnishes.

In a column of three feet diameter, with an expanded iron base of six feet, and a further expansion of the concrete filling to ten feet diameter, and driven forty feet into the earth, the external frictional support would be about 180 tons, and the support from the bottom areas from four to eight hundred tons.

This increased support of three to seven hundred tons, would be obtained by an expenditure of less than a hundred dollars.

The extension of the concrete filling downwards, must, of course, be proportioned to its lateral expansion; that is, the thickness of the concrete beneath the outer periphery of the column must be increased, to bear the increased load which its expansion laterally will enable to be placed on the column.

In this connection, I may remark that the strength of the shell of the iron pile has also a limit; but as that strength will usually be several times greater than the supporting power derived from the earth, it will but rarely become necessary to consider it.

Treated as a column, a tube of three feet diameter, three-fourths of an inch thick, and fifty feet long, between the bridge seat and where it is secured against lateral movement by the surrounding earth, would sustain say seven hundred tons with safety; and, if desired, ribs may be introduced, which, with its flanges, will double or treble this strength.

The method adopted at Harlem at first, was when the column had been driven to the required depth, to drive under its exterior periphery, wooden sheet piles, five feet long, three inches wide and one and a quarter inches thick, on an angle of thirty degrees; but only in sections of a few feet in width at a time. These sheet piles acted merely as a roof or support to the sand above, and if the air presure had been kept up for a day and night beforehand at an extra pressure, it drove out the water from the sand and permitted the excavation to be made in nearly dry earth.

This excavation, however, must be performed rapidly, that is within two or three minutes, or otherwise the pressure of the water and the weight of the superincumbent sand, which then becomes rapidly suffused with water, forces its way through the roof.

If the excavation and concrete filling is quickly done, the operation will always be successful. A little experience on the part of our workmen enabled them to judge whether the earth was in proper condition to give success. This operation was confined to a small section at a time, and these sections were never undertaken contiguous to each other, but always on opposite sides of the circumference of the column.

When a ring of concrete had been put in by the means above stated, it formed an actual prolongation of the depth of the column, and that part of the concrete under it could be extended several feet deep without encountering the water.

The material which was encountered at Harlem in several places, was very fine sand, which is the worst that could have been met with, and therefore I feel assured that this method may be practiced under almost any circumstances that would be likely to occur.

Towards the end of our operations our men became so expert that they would extend the concrete three feet beyond and four feet below the iron column, in fine sand without the use of roofing.

It has been stated that our hydraulic cement will not set in the concrete in these columns. While this is true of concrete, put in large masses at a time, when properly put in, the concrete will set even better than in open air. The cause of this failure is, that the surface sets with extraordinary rapidity in the highly condensed air, and when the concrete is put in, in large masses, the moisture from the interior has no opportunity to escape, and, consequently, it remains in a pasty condition.

To remedy this I used small tubes of iron, passing down through the concrete, vertically, to beneath the bottom, and perforated on their sides, by means of which a film of air was interposed between the exterior water and the concrete, and the condensed air was circulated through the mass of the latter and absorbed its excess of water, and caused the whole mass to set quickly and very strong.

Difficulties have heretofore been met with in the placing of the column and keeping it accurately in position.

There is no occasion for this. If practicable, they should be driven from a platform and not from a float. The bottom of the column should be placed in its precise position, and if care is exercised to keep it plumb while being driven, there is no danger of its divergence at the bottom.

In several cases we encountered the edges of sloping rocks, which did not change the exact perpendicular descent of the column. The columns at Harlem were driven with almost perfect accuracy; none of them varied one inch from the position designed.

The delay and difficulty of driving them through logs and boulder-rocks is much less than might be anticipated. In one of the columns a succession of boulders was encountered, over thirty in number, nearly all of which were so large or so situated, that they had to be cut through. These very unusual obstructions did not delay the sinking of this column more than a fortnight.

In another case a column was driven through the hull of a sunken vessel, when the timber was extraordinarily tough and strongly bolted. This delayed us but two days. We also cut off some very large oak logs.

The cost of removing the excavation from one of the columns was seventy-five cents per cubic yard, though generally it cost double that sum. The indraft of sand was about three times the displacement of the column; though as we acquired experience, we were enabled to materially lessen this indraft.

The force employed upon the various parts of the work was as follows:—

1 Foremen and 3 men within the column.

1 Superintendent, 2 riggers and 4 laborers outside.

1 Engine-man and 1 fireman.

The machinery and tools employed did not cost more than $15,000, and the platform and sheds as much more. But a much larger and better adapted plant ought generally to be provided.

The time occupied in the driving of the columns an average depth of twenty-five feet below the bed of the river, in sand, gravel, boulders and timber, expanding and sealing the bottom with concrete, was from seven to twenty days for each column. The lowest of these figures representing the time required for those presenting but few difficulties or obstructions, and the highest number of days the excess of time required to overcome the most serious difficulties.

It has been stated that generally the water was expelled from the column through its open bottom, but sometimes the earth became so compacted by subsidence, or a stratum of clay was encountered, which presented a barrier to the passage of the water in that direction. In this case it was forced up through a syphon-pipe within the column, and discharging through a curved pipe into the atmosphere near the bottom of the air-lock.

This syphon-pipe was also used as a sand-pump to discharge the material from the column. Although successful and economical, it was attended with too much hazard to the lives of the men within the column to warrant its use.

The rapid consumption of the oxygen of the air within the column by the use of lamps, led us to devise plans for sending down through the bull's eye glasses, reflected light. For this purpose we used common mirrors, which reflected the sun's rays; and the success of that plan demonstrated that sufficient light could be furnished artificially and reflected into the column, to answer all requirements.

During the winter, when the thermometer fell below zero, the workmen complained of cold, and the air forced into the column was first heated by the exhaust steam, discharged into a register.

In midsummer they suffered from the intense heat, which rose to above 100°, and this was moderated by allowing the spray from a stream of water to fall upon and be evaporated from the sides of the cast iron column above the water. A reduction of from 10 to 15 degrees was thus effected.

I have understood that elsewhere work on such columns had to be abandoned during the day, from the excessive heat within the column.

The condensation of the air converts the latent heat in the atmosphere into a specific heat, and raises its temperature ten or fifteen degrees, and when the air was again allowed to escape, it brought the thermometer, placed in the line of its exit, nearly down to the freezing point.

The capacity of the atmosphere for the retention of moisture was beautifully illustrated within the column, when from any cause the pressure of the air was suddenly relieved, which produced a dense fog and deposition of moisture.

The power used for condensing the air was an imperfect six-horse engine, and sometimes the operation in hand required more power than this engine could furnish. We therefore sealed the top and bottom of one of the empty columns, and kept it charged with air at a high pressure, and by means of a flexible pipe to the column which was being sunk, we availed of this additional power.

This reservoir of power was of great advantage in some of the operations, as we could charge the column a second time instantly with air, after it had ceased sinking by the ordinary process, and repeat the sinking process, while the earth adjacent to it was still loose; and it also gave us complete command of the descent of the column, so that we could at any instant check it at the desired point.

The mass of metal which we were handling weighed nearly fifty tons, and with this adjunct we could almost instantly destroy its gravity or restore it at will. It was grand to witness this huge iron tube commencing its descent into the river, at first slowly, but increasing in velocity by its momentum, until it became almost dangerous, when at the turn of ones wrist it was slowed; again it was started and again arrested, and so, by repeated plunges, until it was finally brought up within an inch of the desired depth.

The Harlem work developed two most important points, not hitherto applied to this system of foundations, viz: the large increase of the supporting power by the expanded concrete base, obtained at an insignificant expense, and the increased effect in driving by the use of the air reservoir, as well as the complete control which it gives on the descent of the column.

The duration of the metal under water has been a subject of inquiry. It has been alledged that certain kinds of cast iron, immersed in acidulated water, undergoes an entire change and loses their strength, and it is inferred that foul and salt water will produce the same change to some extent.

This change is confined to graphitic iron; but when the metal is combined with the carbon, as in the white iron, no such change occurs; and as this combination is more and more complete between the soft and hard irons, so does it become less liable to this change. The white and the mottled irons are subject to a slight oxidation when placed under water, but this corrosion is limited to a trifling depth, and it has been asserted that such slight oxidation prevents any further action on the metal. The result of numerous experiments show that with moderately hard iron, the corrosion in salt water will not exceed one-tenth of an inch in a century, and in fresh water will be inappreciable.

The stability against impact of a pier entirely of iron columns, has been proven by the Chepstow, Charing Cross and other foreign bridges, as well as incidentally by those in this country.

One of the columns which had entered the earth but twelve feet and projected above it about thirty feet, and was not filled, was struck a heavy blow by a steamer without affecting it in the slightest degree, and one of the columns at the Pedee was struck by a raft of timber, one-fourth of a mile long, and nearly the width of the river, without effect.

The column in this case was but eight feet into the sand, and was unfilled.

I am of the opinion that an iron pier, made of two columns, filled with concrete, of eight feet diameter, braced together and protected by a wooden or iron starling, will resist, without the slightest injury to itself, the heaviest blows that a steamer, or drift of timber or ice can give to it.

The rapidity with which such piers may be constructed may be inferred from what has been stated. The piers necessary for a bridge across the Mississippi, may be finished ready for the superstructure, in six months from the day upon which the order for their construction is given, and in two-thirds of that time, if it is desired; and this without regard to the weather or freshets in the river. The latter might produce a few weeks delay and a small additional expense, but neither would be of much consequence.

# Mechanics, Physics and Chemistry.

## LECTURE-NOTES ON PHYSICS.

By Prof. Alfred M. Mayer, Ph.D.

(Continued from page 120.)

### § III. *Methods of Precision.*

In § II we described various instruments used in precise measurements, and we will now explain certain methods used, both in making a series of measures on a quantity and in subsequently combining them, so that the final result has the greatest possible accuracy. These methods are designated as *methods of precision.* They can be classed under three heads:—

1. Method of means, or of averages.
2. Method of multiplication.
3. Method of successive corrections.

1. *Method of Means.*—If a series of measurements be taken with an instrument of precision on one and the same quantity, it will be found, when all the measures are made in the same circumstances and with equal care, that they will differ from each other by a *small* amount.

*The mean value* of all the measures is taken when the probability is even that each measure is more or less than the true measure by *a small quantity.* The mean result in this case is the same as if we added the mean to itself as often as there are separate measures, and divided by the number of measures.

The determination of means is of such constant occurrence in physics, astronomy and chemistry, that the discussion of their *degree of precision* is very important. It is founded on the principle of the theory of probabilities; and we will here give a few of its more important results.

Omitting from consideration gross errors, which can always be avoided by operating with care, the causes of the errors of measurements can be classified in two groups, 1. Constant or regular causes; 2. Irregular or accidental causes; whence we have two kind of errors, 1. *Constant or regular errors*, which are reproduced when we repeat the observations in the same circumstances; and 2. *Irregular or accidental errors* of which we are not able to get entirely rid; but which, not being subject to any law connecting them with the circumstances of the measurements, occur indifferently to increase or to diminish the true measure.

*Examples.* A constant cause of error would be an error in the length of the unit used in measuring the base-line of a trigonometric survey. This error will be *regular* and *constant*, and being made every time the unit is applied to the length to be measured, it will be in proportion to this length. It is evident that this error can be allowed for, when we know its amount, and thus our result is the same as if we operated with an accurate unit. As examples of irregular sources of error, we may instance the measurement or sighting of angles in a survey; and the bisection of a line by the reading microscope, or by the telescope of a catheometer.

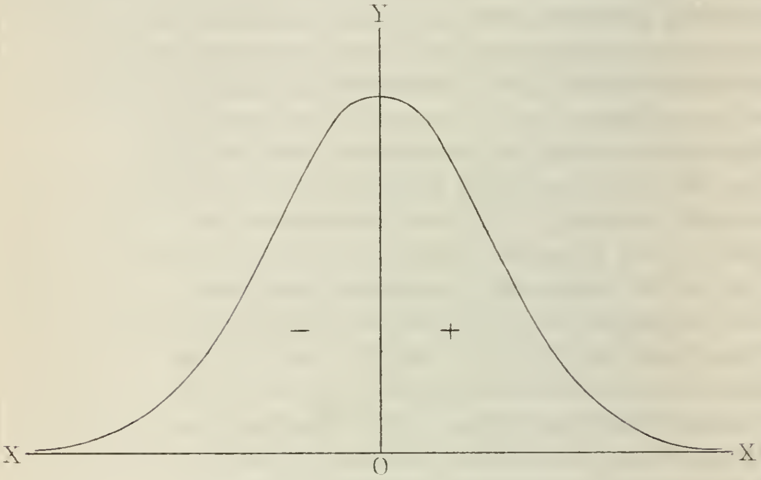
It is evident that *constant errors* are not eliminated by increasing the number of observations; but the *accidental errors* tend to disappear from the mean as we obtain it from a greater number of measures; for this class of errors are as likely to be in one direction as in another in successive trials, and therefore the mean of an *infinite* number of measurements on the same quantity would give the greatest attainable precision, for the quantities would then exactly balance each other in excess and defect.

To find the degree of precision of a mean we divide the whole series of observations into two or three groups, selected at random, and we calculate for each its mean. If these means differ very little we can regard the observations contained in each group as being sufficiently accurate. To proceed thus, we must have a considerable number of observations, and they must not contain very discordant measures. If the partial means do not thus agree, the precision of the general mean is very doubtful.

*Example.* In the observation on the temperature of Providence, R.I., by Prof. A. Caswell, during twenty years, the mean temperature of the first ten years is . . . . . . 48°·1 F.
" " second " " " . . . . . . 48°·3

Difference, . . . . . . . . . . 0°·2
The mean of the whole twenty years is . . . 48°·2

This shows that one decade is sufficient to give the mean temperature to within about one-tenth of a degree.



THE PROBABILITY CURVE

It often happens that we find the measures grouped together in series, depending on the periods or on the various circumstances when they were made. It is then indispensable to calculate the partial means of these series, and if there has existed, during the time of the observations, a constant cause of errors, but of variable intensity, it may manifest itself by taking, as above, the means of several groups.

*Errors of Observation*, called also *residual errors*, are the differences between each particular measure, and the mean of all the measures. These errors are always very small when we operate with care.

The *absolute value* of the quantity sought remaining always unknown, we substitute for it the mean, in the calculation of errors, without which it would be impossible to appreciate them.

When the errors are purely accidental it is found that they can be arranged according to a most remarkable law. If they are grouped by their signs and according to their magnitude, we find that the positive errors and the negative errors are equal in number and in aggregate value, and that they diminish rapidly as we go from the mean, according to a regular law; in other words, the smallest errors are the most frequent and are principally accumulated around their mean value. This remarkable fact is shown in the figure, where, on the left of the axis O Y are placed the differences or errors of observation less than the mean, or —; and on the right those greater than the mean, or +.

Theoretically, this curve, called the *curve of probability*, should be perfectly symmetric and regular. If it departs much from this form it shows that the observations or experiments have not been made with sufficient care, or that their number is insufficient, or that there exists a permanent cause of error arising either from the observer himself (personal equation), or from the manner of operating.

Suppose we have now found a series of measures which, being divided into groups, give as many means which differ by little; that the difference of each mean from the general mean is very small; and, finally, that these errors are distributed about the mean according to the curve of probability; then the cause of the errors is purely accidental, they tend to diappear from the mean, and the *theory of probabilities* gives us the numerical value of the *degree of precision.*

The first principle of this theory is, that *the precision in the mean increases as the square root of the number of observations from* *which it is derived.* Thus, the circumstances in both series of observations remaining the same, from sixteen observations we have in favor of the precision of the mean, a probability twice as great as for four observations.

We must now consider another element, which is, the error of each partial measure, or its departure from the mean.

We call the *mean error* not the arithmetical mean of the errors, but *the square root of the mean of the squares of the errors.* Let $\varepsilon$, $\varepsilon'$, $\varepsilon''$, &c., . . . . . be the errors of observation, their mean error, $e$, will be—

$$e=\sqrt{\frac{\varepsilon^2+\varepsilon'^2+\varepsilon''^2+\quad.\ .\ .\ .\ .\ .}{n}}$$

$n$ being the number of observations.

By means of this *mean error* we can calculate what is called *the probable error*, either of the mean or of a single observation.

*The probable error* is that quantity which has such a magnitude that there is the same probability of the error, in the quantity determined, being greater as there is of its being less by this quantity.

It is demonstrated that the probable error of a single observation is—

$$\frac{2}{3}e.$$

The probable error of the mean result is—

$$\text{E}=\frac{2}{3}\frac{e}{\sqrt{n}}.$$

We thus see that it diminishes in the inverse ratio of the square root of the number of observations.

We will now show from examples, taken from the appendix to Gerhardt's *Traité Elémentaire de Chimie*, how the foregoing principles and formula can serve to indicate the exactness of a series of measures.

M. Dumas made experiments to determine the composition of water, and to verify the theoretical law of Prout, that all the chemical equivalents are exact multiples of that of hydrogen. The equivalent of oxygen being represented by 100, that of hydrogen should be exactly 12·5. But a series of nineteen experiments gave, after the corrections were made, the following numbers, which we arrange according to their magnitude.

| | |
|---|---|
| 12·472 | 12·508 |
| ·480 | ·522 |
| ·480 | ·533 |
| ·489 | ·546 |
| ·490 | ·547 |
| ·490 | ·550 |
| ·490 | ·550 |
| ·491 | ·551 |
| ·496 | ·551 |
| | ·562 |

The mean of the numbers is 12·515; the sum of the squares of the errors is 0·0173; the mean error $e = 0·030$; the probable error of a single observation is 0·020, and the probable error of the mean result $\text{E} = 0·0046$. It would appear from this that an error of 0·015 is impossible, and that the equivalent of hydrogen ought to be above 12·500.

But if we observe attentively the table, we will see that the numbers, instead of being accumulated, according to the law of probability, around the mean, tend rather towards the extremes. The means of the two columns are 12·486 and 12·542, which differ too much to accept the hundredths when we unite them. It therefore follows that the method of experiment by which were obtained the numbers, is too gross to decide that the equivalent of hydrogen departs from 12·5, and we cannot therefrom decide against the law of Prout.

We see from this example, taken from *The Theory of Chances*, by M. Cournot, how important it is, before drawing our conclusions, to examine with care the individual observations whence we deduce the mean, so that we may satisfy ourselves of their exactitude.

We often exaggerate the accuracy attained, which is necessarily limited. A quantity cannot be estimated to an indefinite precision even when the observations are indefinitely extended. In the measure of a length, for example, whatever care we may take we can seldom surely rely on more than five figures. Thus, one of the base-lines in the triangulation of France was found to be 6075·9 toises; we find that there can easily occur in this number an error of $0^{t}{\cdot}1$. In the estimation of weights there is also a limit of precision which we cannot surpass, whatever may be the accuracy of the balance and the skill of the operator. Here also we cannot rely on more than five significant figures.

Still greater reason is there for care in assuming a certain precision of result when the measure is the result of several different physical operations, each of which brings with it its own error. In the determination of the number $g = 9^{\text{m}}\cdot809$, which represents the intensity of gravity at Paris, (or the velocity acquired by a body after falling one second,) the four figures which we have given are those only on which we can rely, and it would be altogether illusory to extend the decimal. If we compare the numbers found by able observers, we find that they differ even in this fourth figure.

| Intensity of gravity at Paris. | Length of second's pendulum. |
|---|---|
| Borda, $9^{\text{m}}\cdot8089$ | $0^{\text{m}}\cdot99385$ |
| Biot, $9\ \cdot8091$ | $\cdot99387$ |
| Bessel, $9\ \cdot8094$ | $\cdot99390$ |

For the length of the second's pendulum we should take $0^{\text{m}}\cdot\cdot9939$, but remembering that we can barely rely upon the result to $\frac{1}{10}$th of a millimetre.

Physicists and chemists have often to estimate the exactness it is possible to attain in the determination of densities and equivalents. By repeating these operations several times in succession, by varying the methods, by taking different specimens of the same body, and finally, by submitting the results to the numerical tests which we have indicated, we arrive at the degree of precision of the results.

We thus find that the number of *certain* figures in this class of determinations is less than we would *à priori* have supposed, and that no more reliance is to be placed in several of the decimals that are usually retained, than if we wrote them down at random. We can often discover this influence of chance in a series of measures. and distinguish those decimal figures which we ought to suppress as being altogether arbitrary, since they are less than the errors of observation. Suppose that we estimate a length which can only be appreciated to a millimetre; if we retain the tenths of millimetre, they will be entirely of an arbitrary value. The figures written in the tenths will be irregular in the successive measures, absolutely, as if we obtained them by drawing at random, out of our pocket, marbles having pasted on them the figures 0, 1, 2, 3, 4, 5, 6, 7, 8, 9. But, as the mean of these ten figures is 4·5, it follows that if we have a great many results, the mean of the figures of tenths of millimetre will be exactly 4·5. And *vice versa*, if in a long series of numbers, given by observation, we find that the mean of all the decimal figures of the last order is 4·5, we can omit them. If it is the same with the figures of the next higher order, we suppress them also and so on.

M. Schrötter determined the equivalent of phosphorus, by weighing the phosphoric acid produced in the combustion of a known weight of that element. These experiments were made upon amorphous phosphorus, previously dried at 150° C., in an atmosphere of carbonic acid or of hydrogen. The transformation of the phosphorus into phosphoric acid, was effected in a combustion tube, through which passed a current of perfectly dry oxygen. After the combustion, the phosphoric acid was sublimed in an atmosphere of oxygen, so as to oxydise any traces of phosphorus acid which might have been produced.

The following are the results:—

| | |
|---|---|
| Phosphoric acid produced by one part of phosphorus. | 2·28909<br>·28783<br>·29300<br>·28831<br>·29040<br>·28788<br>·28848<br>·28856<br>·28959<br>·28872 |
| Mean, . . . . . | 2·28919 |

We find that the sum of the figures of the last column on the right is 46, the mean of which is 4·6, since there are ten results. In the same manner the mean of the next column, to the left, is 4·4. We therefore retain only the first three decimal figures, the remaining two being solely due to hazard. This done, if we calculate the error of each observation, or the departure from the mean, we will find that the sum of the squares of these errors is 0·000022; the mean error $e = 0{\cdot}0015$, the probable error of a single observation is 0·001, and the probable error of the mean is $\text{E} = 0{\cdot}0003$.

We can therefore admit that one part of phosphorus gives 2·289 of phosphoric acid, and that the error of this result certainly does not exceed six times the probable error, that is to say, 0·002. The corresponding equivalent of phosphorus is 31·027, and its probable error $= 0{\cdot}004$, which is expressed thus—

$$31{\cdot}027 + 0{\cdot}004.$$

But that supposes that the analyses are only effected with accidental errors, while it may readily happen that they are subject to a constant error. It would then follow that the figure of the hundredths could not be regarded as certain; therefore M. Schrötter adopts simply 31 as the final result of his researches.

It is from the constant errors existing that we may err in the conclusions that we prematurely draw from the calculation of the mean of the probable errors. And it often happens that subsequent observations show that the mean adopted at first is affected with an error far exceeding the probable error which we attributed to it.

It is a characteristic of the arithmetical mean, that it makes *the sum of the squares of the residual errors a minimum.*

To illustrate this principle geometrically, suppose that several observations, made to determine the position in space of a point, A, give several positions around the true point, A. Connect the points given by observation by straight lines; then the centre of figure or centre of gravity of the polygon, which is formed by joining these points, is evidently the most probable position of A. Draw lines from the angles of the polygon to its centre of figure; then these lines will represent the several errors of the observations. Now, it is a property of the centre of gravity of such a polygon, that the sum of the squares of these lines is less than the sum of the squares of similar lines drawn to any other point within the polygon. Therefore, *if the sum of the squares of the errors is the least possible, we have the nearest mean we can obtain from the observations.*

This is the fundamental principle of the celebrated theorem of *Least Squares*, of Gauss and of Legendre, which has rendered such inestimable service to physics and astronomy.

Suppose that, instead of having to determine, as in the above examples, a single unknown quantity—which is the mean of the several observations,—we propose to determine several unknown quantities entering as functions in equations. As observations or experiments give the known quantities of these equations, we will have as many equations as there are observations. Having, for example, two quantities to be determined, $x$ and $y$, suppose that we have made three observations, giving three equations. The values of $x$ and $y$ deduced from two of these equations, will not generally satisfy the third. The difficulty consists in using all the equations at once, so that we can deduce from them a series of values which will satisfy, in the most accurate manner possible, all the equations. The theory of the method of least squares shows, in order that this may happen, that the sum of the squares of the errors must be a minimum.

In a series of observations or experiments, let us suppose that the errors committed are denoted by $e$, $e'$, $e''$, &c., and suppose that by means of the observations, we have deduced the equations of condition—

$$\left.\begin{array}{l} e \;\;\; = h + a\,x + b\,y + c\,z + \&c. \\ e' \;\; = h' + a'\,x + b'\,y + c'\,z + \&c. \\ e'' \, = h'' + a''\,x + b''\,y + c''\,z + \&c. \\ e''' = h''' + a'''\,x + b'''\,y + c'''\,z + \&c. \\ \qquad \&c. \qquad \&c. \qquad \&c. \end{array}\right\} \quad (1.)$$

Let it be required to find such values of $x$, $y$, $z$, &c., that the errors $e$, $e'$, $e''$, $e'''$, &c., with reference to all the observations shall be the least possible.

If we square both members of each equation, in group (1), and add them together, member to member, we shall have—

$$\begin{aligned} e^2 + e'^2 + e''^2 + \&c. = {} & x^2\,(a^2 + a'^2 + \&c.) \\ & + 2\,x \left\{ (a\,h + a'\,h' + \&c.) + a\,(b\,y + c\,z + \&c.) \right. \\ & \left. + a'\,(b'\,y + c'\,z + \&c.) + \&c. \right\} + \&c., \end{aligned}$$

an equation which may be written—

$$e^2 + e'^2 + e''^2 + \&c. = u = P\,x^2 + 2\,Q\,x + R + \&c.$$

Now, in order that $e^2 + e'^2 + \&c.$, or $u$, may be a minimum, it is necessary that its partial differential co-efficients, taken with respect to each variable, in succession, should be separately equal to $O$. Hence,

$$\begin{aligned} \frac{d\,u}{d\,x} = p\,x + q = 0, \text{ or } & x\,(a^2 + a'^2 + \&c.) \\ & + a\,h + a\,h' + \&c. + a\,(b\,y + c\,z + \&c.) \\ & + a'\,(b'\,y + c'\,z + \&c.) + \&c. = O\,; \end{aligned}$$

and similar equations for each of the other variables. Hence, we deduce the principle, that, in order to form an equation of condition for the minimum, with respect to one of the unknown quantities, as $x$ for example, we have simply to multiply the second members of each of the equations of condition by the co-efficient of the unknown quantity in that equation, then take the sum of the products, and place the result equal to $O$. Proceed in this manner for each of the unknown quantities, and there will result as many equations as there are unknown quantities, from which the required values of the unknown quantities may be found by the ordinary rules for solving equations.

Let it be required, for example, to find from the equations—

$$\left.\begin{array}{r}3 - x + y - 2z = 0\\ 5 - 3x - 2y + 5z = 0\\ 21 - 4x - y - 4z = 0\\ 14 + x - 3y - 3z = 0\end{array}\right\} \quad (2),$$

such values of $x$, $y$, and $z$, as will most nearly satisfy all of the equations.

[It is to be remarked, that we must necessarily admit that these equations already approximate closely in value, that is to say, that the values of $x$, $y$, and $z$ deduced from the three first will satisfy approximately the third; without this, the problem is absurd, and the observations which have given these equations are unworthy of confidence.]

"Following the rule, and multiplying the first member of each equation by the co-efficient of $x$ in that equation, we get the products—

$$\begin{array}{r}-3 + x - y + 2z\\ -15 + 9x + 6y - 15z\\ -84 + 16x + 4y + 16z\\ 14 + x - 3y - 3z,\end{array}$$

and placing their algebraic sums equal to $0$, we have—

$$27x + 6y - 88 = 0, \quad . \quad . \quad . \quad . \quad (3.)$$

Proceeding in like manner with respect to the unknown quantities $y$ and $z$, we obtain the equations—

$$6x + 15y + z - 70 = 0, \quad . \quad . \quad . \quad (4.)$$

$$y + 54z - 107 = 0, \quad . \quad . \quad . \quad . \quad (5.)$$

Combining equations (3), (4), and (5), we find—

$$x = 2{\cdot}4702,\ y = 3{\cdot}5507, \text{ and } z = 1{\cdot}9157,$$

which most nearly satisfy all of the equations in group (2).

To show the practical application of this principle, we will suppose that it is required to investigate the values of a constant in an equation, by means of several independent experiments.

It is demonstrated from theory that the length of the pendulum which beats seconds, in any latitude, is given by the formula—

$$L = x + y \,\text{sin.}^2\, l, \qquad . \qquad . \qquad . \qquad . \qquad (6.)$$

in which $L$ denotes the length of the pendulum; $l$ the latitude of the place on the surface of the earth, and $x$ and $y$ are constants to be determined. In consequence of errors incident to observation, the values of $x$ and $y$ cannot be accurately determined by means of a single observation; taking the *metre* (denoted by $m$) as the unit of measure, suppose that the length of the second's pendulum has been measured in six different places, whose latitudes are known, and that the following equations have been deduced:

$$\left.\begin{aligned}
e' &= x + y \times 0^{\mathrm{m}}.3903417 - 0^{\mathrm{m}}.9929750 \\
e'' &= x + y \times 0^{\mathrm{m}}.4972122 - 0^{\mathrm{m}}.9934620 \\
e''' &= x + y \times 0^{\mathrm{m}}.5667721 - 0^{\mathrm{m}}.9938784 \\
e^{\mathrm{iv.}} &= x + y \times 0^{\mathrm{m}}.4932370 - 0^{\mathrm{m}}.9934740 \\
e^{\mathrm{v.}} &= x + y \times 0^{\mathrm{m}}.5136117 - 0^{\mathrm{m}}.9935967 \\
e^{\mathrm{vi.}} &= x + y \times 0^{\mathrm{m}}.6045628 - 0^{\mathrm{m}}.9940932
\end{aligned}\right\} \quad (7.)$$

Applying the rule already deduced, to these questions, we find the equations—

$$6x + y \times 3^{\mathrm{m}}.0657375 - 5^{\mathrm{m}}.9614793 = 0, \qquad . \qquad . \qquad (8),$$

$$x \times {}^{\mathrm{m}}.0657375 + y \times 1^{\mathrm{m}}.5933894 - 3^{\mathrm{m}}.0461977 = 0, \quad (9.)$$

Combining equations (8) and (9), we obtain—

$$x = 0^{\mathrm{m}}.9908755, \; y = 0^{\mathrm{m}}.0052942.$$

Substituting these in equation (6), it becomes—

$$L = 0^{\mathrm{m}}.9908755 + 0^{\mathrm{m}}.0052942 \,\mathit{sin.}^2\, l, \qquad . \qquad . \qquad (10.)$$

By means of formula (10), the length of the second's pendulum may be found, by computation, at any place whose latitude is known. In like manner, the method of least squares may be applied to a multitude of similar cases." (See art. *Least Squares, Dict. of Mathematics*, by Davies and Peck, N. Y., 1865.)

It is impossible, in lectures of this character, to give more than an idea of this fertile principle of *Least Squares*. The reader is referred to the following works for a full discussion of the method. *Méthode des moindres carrées; Mémoires sur la combinaison des observations, par Ch. Fr. Gauss, traduit par J. Bertrand*, Paris, 1855; also *Method of Least Squares*, by Prof. William Chauvenet, in the appendix to his *Spherical and Practical Astronomy*, Phila., 1863. From this work the figure of the probability curve is taken.

### 2. *Method of Multiplication.*

The method of multiplication consists in measuring a known multiple, by $n$, of the quantity to be determined, and then dividing the result by $n$. By this method the error, committed in the direct measure, is divided by $n$.

*Example* 1. To find the diameter of a fine metallic wire, we wrap a certain number of turns, say 200, of the wire on a metal cylinder, taking care to press the coils until all are in contact. Measure the length of the 200 coils, and dividing this length by 200, we have—supposing all the coils are formed of wire of the same diameter—the diameter of the wire to the $\frac{1}{200}$th of the error committed in the measure of the length of the 200 coils. Suppose, for example, we have made an error of $\frac{1}{20}$ inch in measuring the length of 200 coils; then the error in the determination of the diameter of the wire is $\frac{1}{200}$ of $\frac{1}{20}$ or the $\frac{1}{4000}$th of an inch.

*Example* 2. By a similar operation we determine, with great accuracy, the distance between the contiguous threads (called *the pitch*) of a micrometer screw.

*Example* 3. Saxton's Reflecting Comparator is a beautiful illustration of the principle of multiplication, in which the direct measure is a very large multiple of the quantity whose value we desire.

*Example* 4. We may obtain a very accurate determination of the weight of a body, with a balance with equal arms, by equilibrating the body with shot, &c., placed in the other pan; then placing the body in the same pan with the shot, &c., we obtain in the other pan, in shot, *twice* the weight of the body. We now add the shot of twice the weight of the body, to the pan containing the body, and on again equilibrating, we have in the pan opposite the body, a weight of shot equal to *four times* the weight of the body, and so on. We finally have in a pan a known multiple, by $n$, of the weight of the body, which, divided by $n$, gives the weight we seek.

*Example* 5. *The Method of Repetition.*—Describe the method with the aid of diagrams. It is a very ingenious application of the method of multiplication to the measurement of angles, by means of the *repeating circle*, invented by Tobias Mayer, of Göttingen, in 1762, and subsequently improved by Borda, of Paris.

### 3. *Method of Successive Corrections.*

This method, used frequently in astronomy, is also often employed in researches in Physics. We will explain it by an example (from *Daguin's Traité de Physique*, vol. i., page 30). Let it be proposed to determine the capacity of a ground glass-stoppered flask. If we knew the weight of the water at 4° C., which the flask holds, then just as many grammes as there are in this weight, are there cubic centimetres in the flask: for a gramme is the weight of one cubic centimetre of pure water at 4° C. It is, therefore, required to determine the weight of the flask-full of water at 4° C., which we suppose is the temperature when the experiment is made. We first weigh the flask, full of air, then full of water at 4° C. Let $p$ and $P$ be the two weights, respectively. $P-p$ will represent the weight of the water, if the flask, during the first weighing, had contained no air, whose weight is added to that of the flask. The value $P-p$ is therefore too little by the weight of that quantity of air. Suppose that the water at 4° C., weighs $n$ times as much as an equal volume of air, taken at the same atmospheric pressure and temperature as in the experiment. We will see further on how this number $n$ is obtained. The weight of the air which fills the flask will then be $(P-p)\frac{1}{n}$, if we suppose for the moment that $P-p$ is the exact weight of the water. Then the weight of the water which fills the flask will be—

$$(P-p)+(P-p)\frac{1}{n}=(P-p)\left(1+\frac{1}{n}\right). \qquad (1.)$$

This expression, however, does not represent the exact weight of the water, because the term $(P-p)$, and consequently the term $(P-p)\frac{1}{n}$, are too small. But the error which exists in value (1) is less than that which affects the value $P-p$. If we now employ the value (1) to calculate the weight of the air, this weight will be—

$$(P-p)\left(1+\frac{1}{n}\right)\frac{1}{n};$$

and the weight of the water will become—

$$(P-p)+(P-p)\left(1+\frac{1}{n}\right)\frac{1}{n}=(P-p)\left(1+\frac{1}{n}+\frac{1}{n^2}\right). \qquad (2.)$$

a value which is a still greater approximation to the true value, and which, multiplied by $1:n$, will give the weight of the air with still greater precision.

By adding this weight to P—$p$, we will have for the weight of the water—

$$(P-p)\left(1+\frac{1}{n}+\frac{1}{n^2}+\frac{1}{n^3}\right);$$

nearer than any of the preceding values. By continuing in this manner, we can carry the approximation as far as we desire.

(To be continued.)

# FLAME REACTIONS.

By Prof. Bunsen.

Translated by Prof. Charles F. Himes, Ph. D., Dickinson College, Carlisle, Pa.

(Continued from page 130.)

## I.—Behavior of Tellurium Compounds.

A. *Flame coloration*, in the upper reducing flame, pale blue, whilst the oxidizing flame above appears green.

B. *Volatilization* unaccompanied by any odor.

C. *Reduction incrustation*, black, with dark brown coating, dull or brilliant; heated with concentrated sulphuric acid gives a carmine red solution.

D. *Oxide incrustation*, white, scarcely or not at all visible; protochloride of tin colors it black, by reason of separated tellurium; nitrate of silver, after ammonia has been blown upon it, yellowish-white.

E. *Iodide incrustation*, dark brown, with brown coating; disappears transitorily when breathed upon; disappears easily, permanently, when ammonia is blown upon it, and does not reappear upon gently warming it, but does over hydrochloric acid; blackened by protochloride of tin.

F. *Sulphide incrustation*, dark brown to black; does not disappear when breathed upon; dissolves in sulphide of ammonium blown upon it, and reappears upon warming, or upon drying it by blowing upon it.

G. *On a charcoal rod with carbonate of soda*, gives telluride of sodium, which, when moistened upon a silver coin, produces a black spot, and if the test specimen contains much tellurium, with hydrochloric acid, diffuses an odor of telluretted hydrogen with the separation of black tellurium.

### II.—BEHAVIOR OF SELENIUM COMPOUNDS.

A. *Flame coloration*, pure azure-blue.

B. *Volatilizes*, burning, with the diffusion of the characteristic selenium odor.

C. *Reduction incrustation*, brick-red to cherry-red; at one time dull, at another brilliant, gives when heated with concentrated sulphuric acid, a dirty green solution.

D. *Oxide incrustation*, white; brick-red from separated selenium when protochloride of tin is dropped upon it; the red color is rendered darker by hydrate of soda; with nitrate of silver the oxide incrustation gives a white, scarcely visible coloration, which disappears when ammonia is blown upon it.

E. *Iodide incrustation*, brown, contains some reduced selenium, and therefore cannot be made to disappear completely, either by breathing upon it or by blowing ammonia upon it.

F. *Sulphide incrustation*, yellow to orange-red, insoluble in water, soluble in sulphide of ammonium. Since the sulphide incrustation is produced from the iodide incrustation, it consequently also contains some reduced selenium, and therefore does not give very clear reactions.

G. *Reduction with carbonate of soda on the charcoal rod* gives selenide of sodium, which produces with a drop of water a black spot upon a silver coin, and moistened with hydrochloric acid, if the quantity of the substance was not too small, diffuses the odor of selenuretted hydrogen with the separation of red selenium.

### III.—BEHAVIOR OF ANTIMONY COMPOUNDS.

A. *Flame coloration*, upon treatment in the upper reducing flame, greenish pale, accompanied by no odor.

B. *Reduction incrustation*, black, at one time dull, at another brilliant.

C. *Oxide incrustation*, white; gives, when moistened with perfectly neutral nitrate of silver and then treated with ammonia, blown upon it, a black spot of antimonate of sub-oxide of silver, which does not disappear when ammonia is dropped upon it. If the incrustation is first treated with bromine fumes, the reaction will not take place, by reason of the oxidation of the antimonious acid* to antimonic acid. The incrustation is not affected by protochloride of tin, with or without hydrate of soda.

D. *Iodide incrustation*, orange-red, disappears when breathed upon, reappears upon blowing it dry, or gently warming it; disappears permanently when ammonia is blown upon it, reappears again upon treatment with hydrochloric acid vapor. In other respects, gives the same reactions as the oxide incrustation.

E. *Sulphide incrustation*, orange-red, even the coating is made to disappear with considerable difficulty by blowing sulphide of ammonium upon it; upon blowing it dry, it reappears again; insoluble in water.

F. *On charcoal rod with carbonate of soda* does not give a mass which tarnishes silver, but a brittle, white crystalline metallic grain.

## IV.—BEHAVIOR OF ARSENIC COMPOUNDS.

A. *Flame coloration*, in upper reducing flame, pale blue, with the diffusion of the well known arsenic odor.

B. *Reduction incrustation*, black, dull or brilliant, with brown coating.

C. *Oxidation incrustation*, white; when brushed with perfectly neutral nitrate of silver, and ammonia then blown upon it, gives a lemon-yellow precipitate, which can be made to disappear by blowing ammonia upon it. Besides the yellow precipitate, usually a brick-red one of arsenate of silver occurs, which appears alone if the incrustation is previously treated over vapor of bromine. Protochloride of tin, with and without hydrate of soda, does not change it.

D. *Iodide incrustation*, egg-yellow, disappears transitorily when breathed upon; disappears permanently when ammonia is blown upon it; reappears unchanged by means of hydrochloric acid fumes.

E. *Sulphide incrustation*, lemon-yellow, easily made to disappear by blowing sulphide of ammonium upon it, reappears when dried by blowing, or upon warming; insoluble in water, and does not disappear when breathed upon.

F. *Reduction on charcoal rod* produces no metallic grain.

## V.—BEHAVIOR OF BISMUTH COMPOUNDS.

A. *Flame coloration*, bluish, not characteristic.

B. *Reduction incrustation*, black, dull or brilliant; coating bistre.

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* Antimonate of ter-oxide of antimony.—(TR).

C. *Oxide incrustation*, faintly yellowish; unchanged by nitrate of silver either alone or with ammonia; with protochloride of tin alone, also gives no reaction, but after the addition of hydrate of soda, becomes black by reason of the binoxide of bismuth formed.

D. *Iodide incrustation* is very characteristic, and remarkable for the beauty and variety of its shades of color; it is brown to dark brown, with a trace of lavender blue; the coating passes through flesh-red to aurora-red; it disappears readily when breathed upon, and reappears when dried by blowing upon it. The incrustation, when ammonia is blown upon it, passes through aurora-red to egg-yellow, and reappears, when dried by blowing upon it or upon warming, with chestnut-brown color. Toward protochloride of tin and hydrate of soda, it behaves as the oxide incrustation.

E. *Sulphide incrustation*, umber-brown, with coffee-brown coating, does not disappear when breathed upon, and is insoluble in sulphide of ammonium.

F. *On charcoal rod with carbonate of soda* the compounds of bismuth are reduced to a metallic grain, which, when rubbed, gives brilliant yellowish metallic spangles, which are soluble in nitric acid. The solution gives with protochloride of tin and hydrate of soda, black binoxide of bismuth.

## VI.—REACTION OF MERCURY COMPOUNDS.

A. *Metallic incrustation*, mouse-grey, diffused disconnectedly over the whole porcelain capsule. In order to obtain slight traces of mercury reduced, the dry test specimen is mixed with a mixture of carbonate of soda and nitrate of potash, and placed in a test tube of thin glass, 5—6 millimetres wide, 10—20 millimetres long, which is heated on a platinum wire in the flame, whilst the convex bottom of the porcelain capsule, filled with water, touches the upturned mouth of the test tube. If the quantity of mercury is more considerable, the metal is obtained in the form of globules, recognizable under a lens, which unite to form larger globules when brushed with moistened blotting paper.

B. *Oxide incrustation* cannot be produced.

C. *The iodide incrustation* is obtained in the following way: The metallic incrustation is breathed upon, and then placed upon the mouth of a wide-necked bottle, Fig. 8, containing moist bromine. It first becomes black, and thereupon disappears, though only *after considerable time*, being converted into bromide of mercury. If the capsule is now placed over fuming hydriodic acid, the very characteristic carmine-red incrustation of iodide of mercury appears, often still accompanied by the yellow incrustation of subiodide, neither of which disappears when breathed upon, nor when ammonia is blown upon it.

D. *Sulphide incrustation*, black, does not disappear when breathed upon, and insoluble in sulphide of ammonium.

E. *On charcoal rod with carbonate of soda* gives no reaction.

## VII.—BEHAVIOR OF THALLIUM COMPOUNDS.

Since even several millionths of a milligramme of thallium can be recognized by means of the spectroscope, a case seldom occurs in which this metal is detected in any other way. I give the following reactions, therefore, only for the sake of completeness.

A. *Flame coloration*, bright grass-green.

B. *Metallic incrustation*, black, with coffee-brown coating.

C. *Oxide incrustation*, colorless; unchanged by protochloride of tin alone, or with hydrate of soda; also no reaction with nitrate of silver, either with or without ammonia.

D. *Iodide incrustation*, lemon-yellow, does not disappear when breathed upon, nor when ammonia is blown upon it; insoluble in ammonia.

E. *Sulphide incrustation*, obtained from the oxide incrustation, black, with livid coating, insoluble in liquid sulphide of ammonium.

F. *On charcoal rod with carbonate of soda*; reducible to a white ductile metallic grain, which becomes rapidly covered with oxide in the air, and is with difficulty attacked by hydrochloric acid.

Besides the metals belonging to group A 2, which have been considered, there are two others, tin and molybdenum, which could be assigned to the same group. The reduction of these two substances cannot, however, be effected in cases of all compounds, and on account of the slight volatility of these metals is accomplished with difficulty, so that it is better to assign them to groups B 2, B 1 *b*, since they can be most readily recognized by the characteristic reactions of these groups.

(To be continued.)

# METHOD OF QUALITATIVE ANALYSIS OF ANIMAL AND VEGETABLE COLORING MATTERS BY THE SPECTRUM MICROSCOPE.

By H. C. Sorby, F. R. S., &c.

(Continued from page 61.)

From the Proceedings of the Royal Society, No. 92.

In spectra showing one absorption band, there is very commonly a general absorption, extending from it towards the blue end; whereas it so seldom extends towards the red end that it is doubtful if it ever occurs in substances, undoubtedly not a mixture of two colors. It can, however, so easily occur in mixed colors, that any substance giving rise to such a spectrum is probably a mixture. Many illustrations might be given, but I will select Brazil wood, and the same artificially mixed with the color of beet-root. Adding bicarbonate of ammonia to both, we have—

*

Brazil-wood alone ...... $4\frac{3}{4}$—$5\frac{3}{4}$ ... 7

*

Brazil-wood and beet-root $3\frac{1}{2}$ ... $4\frac{5}{8}$—$5\frac{3}{4}$ ..... 8

Here, then, the shading below the absorption band from $3\frac{1}{2}$ to $4\frac{5}{8}$ is evidence of the second color, and if such a mixture had occurred naturally, its mixed character might easily have been overlooked. I have found many cases similar to this, and had proved that they were mixtures, before I was aware that the spectra indicated it. If these very common facts turn out to be general laws, we might thus detect at once the presence of as many as three different substances, or, at all events, might learn what further examination was desirable.

### 15. *Sulphite of Soda.*

Sulphite of soda is a most valuable reagent, and its action very remarkable. It enables us to divide colors into three groups, according as it produces a change in an ammoniacal, or acid solution, or in neither. The action is related in a very simple manner to the spectra. Having added an excess of ammonia, there may be a well marked broad absorption over more or less of the red, orange, yellow, and upper green; and above this a clear, transparent space, limited by a variable amount of absorption, extending downwards from the extreme blue. Fig. 2 will illustrate my meaning. In the case of one group of colors, the addition of sulphite of soda almost immediately removes the detached, broad absorption in the lower part of the spectrum, but leaves that at the blue end quite unchanged, or only slightly modified by the solution being made more alkaline. If, then, as in the case of magenta, there is no absorption at the blue end, sulphite of soda makes the solution quite colorless;

whereas if the blues are absorbed, as in the case of the ammoniacal solutions, of the color of red roses, and some species of *Dianthus*, it changes the color from green to yellow. If the absorption extends continuously down from the extreme blue to the orange, as often happens when ammonia is added to yellow colors, sulphite of soda produces no change. It is only when there is a more or less perfect *division* between the upper and lower absorption, that it has any effect; and then it simply and entirely removes the lower absorption. Some colors are changed immediately, even when a very small quantity of sulphite is added; but others require more, and change gradually, though still very soon.

### 16. *Groups A, B, and C.*

Colors which are thus altered when the solution is ammoniacal, constitute my group A. Frequently, however, sulphite of soda does not remove the detached absorption when excess of ammonia is present, but does so when there is an excess of citric acid. These constitute my group B. As in the other group, any absorption which extends continuously from the extreme blue end is not altered, but the detached absorption in the green is almost immediately removed; and therefore a deep pink or red solution may at once become quite colorless, or only a very pale yellow; and in many cases this residual color is due to some yellow coloring-matter mixed with the other. I have never seen a color which was changed by sulphite when alkaline, and not when acid; and thus citric acid never restores the color when it is added to the changed ammoniacal solution. Excess of ammonia usually restores the faded acid solution to nearly the original color, and it is therefore not a case of actual decomposition, but merely the result of some remarkable molecular change. A third group of colors consists of those which are not almost immediately changed by sulphite of soda, when either alkaline or acid; and these I call group C. Some of them may fade on keeping several hours, and some do not fade even in several days, but they cannot thus be divided into two definite groups. When thus faded, ammonia does not restore the color; and therefore it is evidently the effect of decomposition, and not like the mere molecular change met with in group B.

On the whole, the groups A, B and C are remarkably distinct. There are, indeed, a few cases where the change takes place somewhat slowly; and a few scarlet colors do not show very distinctly the characteristic peculiarities of either B or C; but there are other very strong reasons for believing that some of these are really mixtures of different groups. Even if it should be found that perfectly simple coloring-matters may have, as it were, intermediate characters, such appear to be so rare that practically they may be classed with mixtures, until some reason be found for classing them together as exceptions.

These reactions of sulphite of soda are so much interfered with by the presence of alcohol, that it should never be employed as a solvent, unless the substance is insoluble in water; and then it should be diluted as much as possible, since the ordinary spirit of wine with an equal quantity of water is the extreme strength admissible, and even that very much delays the reaction. The effect of various other reagents is also sometimes very different, according to the nature of the solvent.

The three groups A, B, and C differ in other particulars. It is easy to change A or B into C by various reagents which produce decomposition, but I do not know a case where C can be changed into A or B. Caustic alkalies usually soon decompose colors belonging to group A, when dissolved in water, but act slowly on those of groups B and C. Usually colors of group C are far more permanent than those of groups A and B, and to it belong most of the vegetable colors used in dyeing, and nearly all yellows.

### 17. *Other Reagents.*

*Boracic Acid.*—The chief value of this reagent is, that it gives nearly the same spectrum as that of a neutral solution when added after the addition of a slight excess of ammonia. It should therefore be well fused in a platinum crucible and recrystallized, so as to be quite free from any stronger acid.

*Sulphate of Iron.*—Sulphate of the protoxide of iron is chiefly useful as a deoxidizing agent, in the case of blood and a few analogous substances, taking care to have citric acid present to prevent the precipitation of the oxide by ammonia.*

*Alum.*—Alum has a remarkable influence on some colors, and it has the property of gradually restoring many after they have passed into the faded modification. Many colors also may be kept for a long time dissolved in a strong solution, sealed up in tubes; and it is occasionally an excellent solvent for substances insoluble in either water or alcohol. The chief objection to it as a reagent is that the spectra are so much influenced by the presence of ammonia, even when neutralized by an acid, that it is almost impossible to compare together different substances under exactly the same conditons.

*Iodine and Bromine.*—Iodine dissolved in alcohol, and bromine in water, are useful in producing decompositions, which may differ very considerably in colors which are otherwise very similar; as, for example, the yellow coloring-matters of the root of rhubarb and of turmeric. The iodine or bromine should be added in sufficient quantity, and then ammonia used to remove the excess, and thus avoid the effect of their own color. The solution may then be made acid with citric acid, and should in both cases be compared with another tube to which no iodine or bromine has been added.

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* See Stokes's Paper, Proceed. Roy. Soc. vol. xiii. (1864) p. 355.

*Hypochlorite of Soda.*—This reagent, with or without the addition of citric acid, is sometimes useful, as for instance in detecting the adulteration of rhubarb with turmeric; but generally its action is too powerful and too uniform.

*Permanganate of Potash.*—This also usually acts too powerfully on coloring-matters. The excess can easily be removed by sulphite of soda, which makes an alkaline solution pale yellow, but an acid solution quite colorless.

### 18. *Grouping of Colors.*

Having now considered some of the chief peculiarities of the most useful reagents, I proceed to describe what appears to me the most convenient method of dividing coloring-matters into groups and subgroups, so as to enable us to ascertain the nature of any particular substance under examination. The number of distinct colored compounds met with in different plants, is so great, that some such classification is imperative. In the first place, we cannot do better than divide them according as they are soluble in water or alcohol. This may be looked upon as a *chemical* division, and is very useful in practice. Thus:

| | | |
|---|---|---|
| Soluble in water and not precipitated by alcohol . . | Division | 1. |
| Soluble in water and precipitated by alcohol . . . | " | 2. |
| Insoluble in water but soluble in alcohol . . . . . | " | 3. |
| Insoluble both in water and alcohol . . . . . . . . | " | 4. |

Of course cases occur which cannot be unhesitatingly classed with any one of these; but they often form good practical divisions, and necessarily modify the methods requisite for further examination.

### 19. *Method and Order of Experiment.*

If a color belongs to division 1, a small quantity, sufficient for three or four experiments, should be exposed to the vapor of ammonia in a watch-glass, until there is certainly no longer any *free acid*, and then gently evaporated, so that all excess of ammonia may be lost. If not thus made neutral we might be entirely misled; for some pink colors are blues reddened by an acid. A small quantity should then be dissolved in water in one of the small experiment-tubes and the spectrum observed. If too little color has been added to give the characteristic spectrum, more should be introduced; but if any part is entirely absorbed, the cell should be turned sideways, in order to see whether or no some narrow absorption-band occurs there; and then it may be desirable to remove some of the solution, and fill up the cell with water. As a general rule, so much color should be added as to make the darkest part of the spectrum decidedly shaded, but yet not so black as to hide any narrow bands; and if any occur, the solution should be made of such a strength as to show them to the greatest advantage. This can be easily done, after a little practice, and is made much easier by being able to turn the tubes sideways. Having noted the spectrum of the neutral solution, a very small quantity of ammonia should be added, and then a decided excess, the spectra being examined to see if there be any difference; for this is very often the case, and very important facts may be overlooked if too great an excess be added at first. The addition of a small bit of sulphite of soda then shows at once whether or no a color belonging to group A is present; and on adding, excess of citric acid we may also determine whether it chiefly belongs to groups B or C. Ammonia should then be added in excess, which may or may not restore it to the same state as before the addition of the acid. To another portion of color, carbonate of soda should be added, and then excess of citric acid, both spectra being carefully observed; and finally sulphite of soda, which definitely shows whether or no there is any other color than one belonging to group C. Combining the results of the two sets of experiments, we may decide whether it belongs to groups A, B, or C, or is a mixture of any of them. If the substance is insoluble in water but soluble in alcohol, the same experiments should be made, only we must add the color dissolved in alcohol to as much water as can be used without making the solution turbid, and must remember how much the presence of alcohol may interfere with the action of some of the reagents.

Another portion of the neutral color should then be dissolved in as strong alcohol as will give a clear solution, and ammonia, benzoic acid, a little citric acid, and much of it, added one after the other; and all the spectra carefully observed, as well as any other facts which may present themselves.

By thus using three separate quantities of color, and adding reagents one after the other, we may obtain about a dozen spectra, which may differ from one another in important particulars, or in some few cases may be all alike. The experiments are so easily made, that the whole series of twelve spectra may be seen in the space of five minutes; and the total quantity of material need not in some cases be more than $\frac{1}{1000}$th of a grain. The facts thus learned may show that for particular practical purposes some different method could be employed with advantage, and that only one or two simple experiments are needed. For example, suspected blood-stains should be treated in an entirely different manner, as described in my paper on that subject;* and in examining dark-colored wines, in order to form some opinion of their age from the relative quantity of the color belonging to group C, gradually formed by the alteration of the original coloring-matter of the grape belonging to group B, it is only requisite to observe the effect of sulphite of soda after the addition of citric acid. It would, however, extend this paper beyond the limits I have prescribed to myself, if I were to enter into practical applications, and I shall therefore merely give a description of a convenient method of grouping the various colors.

(To be continued.)

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* Quarterly Journal of Science, Vol. II. p. 2[illegible]5.

# EDUCATIONAL

## THE MAGIC LANTERN

### AS A MEANS OF DEMONSTRATION.

UNDER the above caption, we do not mean to confine ourselves to a discussion of the action of the complete instrument named, but propose to include various important uses to which different parts of the apparatus can be applied, with certain additions and attachments. Among these, we shall, in the present case (postponing other matters of a less importance to future numbers), take up the arrangement of apparatus by which may be performed that beautiful experiment illustrating the total reflection of light at the interior surface of a dense body, and commonly designated as

### THE LUMINOUS FOUNTAIN.

We believe that this experiment was first performed by Duboscq, and though often repeated and frequently alluded to in various publications, is generally regarded as presenting great difficulties in its reproduction. Our own experience has, however, shown us that it may not only be repeated with little cost and great ease by any one having the usual appliances of a gas lantern; but that it is an illustration of great beauty and interest, which would amply repay many times the trouble of its development.

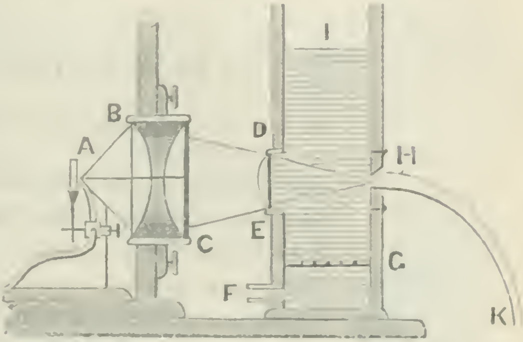
Success, however, depends upon attention to a few particulars, which, to the best of our knowledge, have never been put on record, and we will therefore proceed to give a full description of the same.

Desiring to arrange this illustration, and hearing that Mr. E. S. Ritchie, of Boston, had made very thorough and successful investigations as to its best adjustment, we wrote to him for information, and were furnished by him in the most liberal and amiable manner with full accounts of all essentials, by reason of which we had nothing to do but to put together a few parts as described, in order to secure at once complete success.

The important points, as described by Mr. Ritchie, and verified in our own experience, are these: 1st. Avoidance of currents and commotion in the reservoir. 2d. The employment of a sharp edged diaphragm, very smoothly finished, as a jet.

The entire arrangement of parts is as follows:

Let A represent the line light in the lantern box, and B E the condensers attached to its front, the object glass, tube, &c. being removed. By this means a cone of light is projected upon D E, which represents a plano—convex lens of 3 to 4 inches diameter, and 6 to 7 inches focal length. This lens fits into a cell, against a ring of rubber, upon which it is pressed by a screw cap, so as to render the joint water-tight. The tank P G is made of wood or tin, about 18 inches in height, 5 or 6 inches in the direction D H, and about one foot transversely.



At H is attached a diaphragm, opening, or outlet, flush inside with the front of the tank, sharp edged, and beveling outwards. Near the bottom of the tank is a perforated shelf, or false bottom, E G, below which enters the inlet pipe, F. The shelf, E G, serves to distribute the inflowing water, and prevent violent currents.

Under these circumstances, the water supply being carried to F by a ¾-inch rubber hose from a hydrant, or like supply; is regulated so as to keep a steady level at I (which can be easily recognized by watching the point of contact of the jet, H K, with the basin or reservoir in which it is received), and the light is turned on in the lantern.

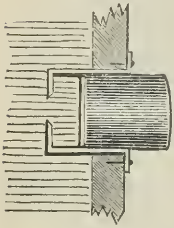
We then have the light from the condensers concentrated at H, and thence issuing with the vein of escaping water, from whose interior surface it is repeatedly reflected so as to follow down the entire length of the jet, which thus becomes brilliantly luminous, appearing as a stream of liquid light, or luminous water.

If the jet is then received in a large glass goblet, or vase, this also, as well as the drops and streams running over and from it, will gleam and glimmer in a beautiful manner. By placing a piece of colored glass in front of the condensers, B C, the stream of light will be converted into a jet of liquid rubies, emeralds, or sapphires, according to the color employed.

If the supply is taken from an ordinary hydrant, the outlet, H, should not be more than 0·5 inch in diameter.

In starting and stopping, it is often desirable to close the outlet, H. To do this, with a cork directly applied, is at once awkward, and likely to injure the smoothness of the edge, which is so important to success. To obviate this difficulty, we propose the following plan:

Let the diaphragm be attached to the end of a short tube, running a little way into the tank, or projecting from it. A cork may then be used to close the outer end of this with ease, and without risk to the diaphragm.



In the experiments which we have made thus far, we have only employed jets of half an inch in diameter, and making streams of 7 to 8 feet in height; but Mr. Ritchie in some experiments made at Boston, with a view of public exhibition on the evening of the Fourth of July, produced successfully, jets of 15 to 20 feet, and 1½ inches in diameter, illuminating them with an electric light from 100 large Bunsen cells.

With regard to the arrangements used for this purpose, Mr. Ritchie tells me, that he carried the water from the street-pipe by fire-engine hose, first to a barrel (which being air-tight, served as an air chamber), thence to a long, erect, conical vessel, having five horizontal partitions pierced with numerous small holes to distribute the flow and avoid strong currents. The side of this vessel, in which the outlet was placed, was flat, and in this the sharp edged opening was fixed. The experiment with these arrangements proved perfectly successful, and was exceedingly beautiful if the air was calm, but the least wind ruffled the jet, and spoiled the effect. Prof. Pepper, as appears in his Play Book of Science, conducted with great success similar experiments in the Sydenham Crystal Palace, but in his description he omits to mention those points which are, as we find, essential to success. In the coming exhibition of the Franklin Institute, next Fall, we hope to develope this illustration on the grand scale.

# KALICHROMATRY.

By Prof. Albert R. Leeds.

Some very pleasing effects may be obtained by superimposing the spectra from two bisulphide of carbon prisms upon the screen with two lanterns, arranged, as is usual, for dissolving views; one is to be pointed upward, through an angle of 64° 16′, the angle of minimum divergence—for a prism of 60° refracting angle—and the other is to be turned away from the screen, through the same number of degrees. Before the objective of the first, a prism is to be held, with its refracting angle upwards; before that of the second, another prism, with its refracting angle vertical. Glass plates, with a coating of blackened collodion or varnish having been prepared, the surface may be scratched away, so as to leave the glasses with one, two, or three horizontal bars, or the upper and lower quarter segments of a circle. These will be brought to a focus by Lantern No. 1, and will produce one, two, or three horizontal spectra, as the case may be. Corresponding glasses are to be prepared for Lantern No. 2, but with the bars vertical, or not differing therefrom by more than 45°. The width of the line should not exceed one-eighth of an inch. In this way the screen may be covered by a cross, or a grating of spectra, giving finely-contrasted tints, or circles, &c., may be formed. These expedients were resorted to, because the diacaustics produced by holding rods of glass, &c., in the path of a single decomposed beam were not satisfactory or brilliant.

# Franklin Institute.

### Proceedings of the Stated Monthly Meeting, January 15th, 1868.

The meeting was called to order with the President, Mr. J. Vaughan Merrick, in the chair.

The minutes of the Board of Managers were reported by the Actuary.

Donations to the Library were received from the Society of Arts, London, and the Association for the Prevention of Steam Boiler Explosions, Manchester, England; la Société d'encouragement pour l'Industrie nationalle, l'Acdemie des Sciences, Paris, and la Société Industrielle, Mulhouse, France; der K. K. Geologischen, Reichanstalt, Vienna, Austria; Major L. A. Huguet-Latour, Montreal, Canada; Hon. Chas. O'Neill, M. C.; Prof. B. Pierce, Superintendent Coast Survey, The U. S. Observatory, Washington, D. C.; The Water Commissioners of Jersey City, N. J.; and from Messrs. S. S. White, Henry Vezin, and J. M. Maich, Philadelphia.

The Annual Report of the Board of Managers was then read.

The result of the election on that day was announced, and the following gentlemen were declared elected as officers of the ensuing year:—

For President, Mr. J. V. Merrick, for one year; for Vice-President, Prof. R. E. Rogers, for three years; for Treasurer, Mr. Frederick Fraley, for one year; for Secretary, Prof. Henry Morton, for one year; for Auditor, Mr. Wm. Biddle, for three years; for Board of Managers, William B. Le Van, Percival Roberts, Jacob Naylor, Samuel Sartain, O. H. Wilson, Charles Bullock, E. Longstreth, Enoch Lewis, for three years; Jacob G. Neaffie, for two years; J. H. Linville, for one year.

The paper announced for the evening, on Pneumatic Piles, was then read by the Hon. W. J. McAlpine, C. E.

The Secretary's report on Novelties in Science and the Mechanic Arts, was read, at the conclusion of which the meeting, on motion, adjourned.

HENRY MORTON, *Secretary.*

# Bibliographical Notices.

*Leaf Prints; or, Glimpses at Photography.* By Charles F. Himes, Ph.D., Professor of Natural Science, Dickinson College, Carlisle, Pa. Philadelphia: Bennerman & Wilson, 1868.

This little book is one that attracts attention immediately by its very beautiful outward form, and gratifies equally by its literary and scientific worth. Professor Himes writes like a scholar and artist. He gives an interesting preface and an admirable introduction to his book, which all may read with pleasure and profit, and then supplies rules and directions for working, so sound and simple, that success must attend the employment of the processes recommended.

The book teaches all lovers of leaf life a short and admirable method by which the most beautiful forms and true foliage may be perfectly reproduced and preserved. A little prepared paper and piece of glass and some sunshine enables any one to transfer to his or her album the graceful forms of any leaves or forms, or the exact patterns of prints, laces and embroideries. The results are so far in advance of any process heretofore employed in producing leaf pictures, that the book can hardly fail to secure a wide circulation. Considering the style in which it is "got up," it is also a very cheap publication.

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*Metals and Grains.—The Merchants' and Bankers' Almanac* for 1868 contains, in addition to a list of 6000 banks and bankers in the United States, Europe, &c., contains the following statistics:

Monthly Prices for Forty Years, of Cotton, Wool, Pork, Flour, Wheat, Corn, Oats, Hops, Iron, Copper, Coal, Coffee, Molasses, Sugar, &c. IX. Annual Product of Wheat, Corn, Rye, Potatoes, in each State, 1866. X. List of New Publications on Banking, Finance, &c. XI. List of Banks, Bankers, Savings Banks, in Canada. XII. Daily Price of Gold, 1863–1867. XIII. Price of Consuls, Annually, 1750–1860. XIV. Fluctuations in 150 Stocks, Bonds, &c., 1867. XV. Progress of Railroads, 1834–1866. XVI. Clearing-House Statistics of New York and London. XVII. Prices of 80 Staple Articles, Monthly, 1869. XVIII. List of 2000 Cashiers. XIX. Prices, Monthly, of American Securities, London, 1867. XX. Engravings of New Bank Buildings. One volume, octavo, 240 pages. Price, $2. Issued at the *Bankers' Magazine* Office, N. Y.

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*Chemical Tables.* By Stephen P. Sharples, S. B.: Sever & Francis.

We have a little book which requires and admits of but little criticism. A few words of description, and an abstract of its table of contents, will be its best recommendation to those whom it concerns. It is a volume of 192 pages, without the least attempt at beauty or elegance in its appearance, but for that reason the more fit to lie upon the laboratory table, and so be always at hand for reference whenever any numerical fact is required. It contains no analytical tables, such as Will's, but all numerical ones which migh by any chance be needed by the practical chemist, manufacturer, or analyst. It can, however, better speak for itself, as thus, in its table of contents: Elements—their equivalents, logarithms, atomic weights, formulæ, per cent. in compounds, factors for analysis, &c., &c. Specific gravities—of elements, of compounds, of important solutions, as ammonia, acids, &c., &c. Tables relating to heat—atomic, specific, and latent heat, expansion of all kinds of bodies, tension of various vapors at various temperatures, heat units evolved by combustion, barometric tables, &c., &c.

Tables relating to light—wave lengths—indices of refraction, &c.

French and English tables compared.

Table of logarithms. (This is but a brief abstract from the contents, which occupies nearly three pages.)

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*A Manual of Inorganic Chemistry, arranged to facilitate the Experimental Demonstration of the Facts and Principles of the Science.* By C. W. Eliot, Professor of Analytical Chemistry and Metallurgy, and Frank H. Storer, Professor of General and Industrial Chemistry, in the Massachusetts Institute of Technology. New York: Ivison, Phinney, Blakeman & Co.

We have here an attempt to give simple and minute instructions in the conduct of experiments, after the example of Stöckhardt, to incorporate a large bulk of purely chemical knowledge, in the manner of Fownes, together with the most important applications of this knowledge, which the works of Miller, Ure, Muspratt, and Watts afford, and, finally, to adapt the explanations and nomenclature to the "new theory."

The authors have executed their task with much skill, labor, and exactness, and to persons not having access to a chemical library the work is particularly valuable. But with all this excellence we apprehend it will not take the place for which it was intended. The simple manipulations of Stöckhardt, which made his chemistry a favorite in ladies' schools and country academies, where the teacher was compelled to keep one hand upon the test-tube, and the other upon the test-book, are lost in a multitude of others, too difficult for the tyro to repeat, and too expensive and complex for the resources of most schools. It would be very gratifying, and we say so in all sincerity, if college students even would look upon such a thorough book with favor; but it is a deplorable certainty, we think, that they would burn it to ashes with ecstatic delight, and regard its teacher as a just object of sophomoric hatred. Its use will probably be restricted to students who have chosen chemistry as a profession, and who are willing to follow instructions with laborious care. To special schools for chemistry, indeed, it is a great boon.

The experiments given exhibit the influence of the exact method of lecture-table demonstration introduced by Hoffinan, whose Modern Chemistry will ever remain as a classic in chemical literature. Chapter XII., on ozone and antozone, has evidently been prepared with great pains, and is probably the best compilation accessible on the different methods of preparation, the tests and properties of these two allotropes. The appendix upon chemical manipulation, in which are included articles upon glass tubing, cutting and cracking glass, blowing bulbs, lamps, bellows, sand baths, pneumatic troughs, etc., gives the methods which the general employment of gas, india rubber, and other modern conveniences have brought into use.

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*Time and Tide.—Twenty-five Letters to a Working-man of Sunderland on the Laws of Work.* By John Ruskin, LL.D., New York: Wiley & Son.

Like former works from their great author, this present short outburst of Ruskin, is able to make the reader pause, reflect, oppose many things vehemently, and end by effecting a certain change of opinion. It has originated in the deep-felt agitation which is spreading from the laboring classes outward through all ranks of English society. It professes to find a remedy for the terrible wrongs and injuries which have grown out of the unequal distribution of riches and land in England, by educating the poor man to make the best of his lot, the lords to the duty of self-denial and unselfishness. It exposes the miserable quality of what are styled amusements, to our contempt; the relative estimate (judged by the sums appropriated) which a Christian community appears to place on art and war, is laughed to scorn. The laws of demand and supply, of rent, etc., are estimated by the light of a wisdom strange to political economists—that of the Bible. Some will call the book Utopian, and its author a dreaming fanatic, but to such an Utopia the world is moving, and such dreamers push with sturdiest hands against the sluggish ball.

A COMPARISON *of some of the Meteorological Phenomena of* JANUARY, 1868, *with those of* JANUARY, 1867, *and of the same month for* SEVENTEEN *years, at Philadelphia, Pa.* Barometer 60 feet above mean tide in the Delaware River. Latitude 39° 57½′ N.; Longitude 75° 11¼′ W. from Greenwich. By PROFESSOR J. A. KIRKPATRICK, of the Central High School.

| | January, 1868. | January, 1867. | January, for 17 years. |
|---|---|---|---|
| Thermometer—Highest—degree | 46·00 | 42·00 | 65·00 |
| “ date | 2d. | 5th. | 29th, '64. |
| Warmest day—mean | 42·00 | 37·00 | 58·33 |
| “ “ date | 2d & 4th. | 6th. | 15th, '63. |
| Lowest—degree | 11·00 | 9·00 | —9·00 |
| “ date | 10th. | 16th. | 8th, '66. |
| Coldest day—mean | 18·67 | 16·00 | —1·00 |
| “ “ date | 13th. | 30th. | 9th, '56. |
| Mean daily oscillation | 11·79 | 10·61 | 11·88 |
| “ “ range | 5·80 | 5·03 | 6·44 |
| Means at 7 A. M. | 27·84 | 23·29 | 27·50 |
| “ 2 P. M. | 33·23 | 29·29 | 34·66 |
| “ 9 P. M | 29·87 | 26·23 | 30·68 |
| “ for the month | 30·31 | 26·27 | 30·95 |
| Barometer—Highest—inches | 30·580 | 30·413 | 30·757 |
| “ date | 31st. | 30th. | 8th, '66. |
| Greatest mean daily pressure | 30·531 | 30·407 | 30·665 |
| “ “ “ date | 31st. | 30th. | 8th, '66. |
| Lowest—inches | 29·291 | 29·337 | 28·911 |
| “ date | 1st. | 21st. | 23d, '53. |
| Least mean daily pressure | 29·450 | 29·426 | 29·086 |
| “ “ “ date | 1st. | 10th. | 23d, '53. |
| Mean daily range | 0·271 | 0·225 | 0·219 |
| Means at 7 A. M | 30·010 | 29·918 | 29·960 |
| “ 2 P. M | 29·986 | 29·883 | 29·920 |
| “ 9 P. M | 30·028 | 29·919 | 29·951 |
| “ for the month | 30·008 | 29·907 | 29·944 |
| Force of Vapor—Greatest—inches | 0·247 | 0·183 | 0·505 |
| “ date | 23d. | 21st. | 11th, '58. |
| Least—inches | ·048 | ·042 | ·023 |
| “ date | 9th. | 30th. | 22d, '57. |
| Means at 7 A. M | ·129 | ·099 | ·131 |
| “ 2 P. M | ·127 | ·109 | ·145 |
| “ 9 P. M | ·135 | ·101 | ·141 |
| “ for the month | ·130 | ·103 | ·139 |
| Relative Humidity—Greatest—per cent | 95·0 | 94·0 | 100·0 |
| “ date | 21st. | 20th. | Often. |
| Least—per cent | 30·0 | 40·0 | 24·0 |
| “ date | 24th. | 5th. | 25th, '60. |
| Means at 7 A. M. | 80·6 | 76·3 | 79·5 |
| “ 2 P. M. | 64·7 | 66·3 | 67·3 |
| “ 9 P. M. | 77·8 | 68·7 | 76·0 |
| “ for the month | 74·4 | 70·4 | 74·3 |
| Clouds—Number of clear days* | 9· | 12· | 9·1 |
| “ cloudy days | 22· | 19· | 21·9 |
| Means of sky covered at 7 A. M | 57·7 per ct | 52·9 per ct | 61·9 per ct |
| “ “ “ 2 P. M | 60·3 | 60·0 | 62·3 |
| “ “ “ 9 P. M | 52·2 | 42·9 | 48·7 |
| “ “ for the month | 56·7 | 51·9 | 57·6 |
| Rain and melted snow—Amount—inches | 3·49 | 1·925 | 3·176 |
| No. of days on which rain or snow fell | 13. | 8· | 10·5 |
| Prevailing Winds—Times in 1000 | N79°43′W·265 | N69° 9′ W·424 | N62°58′W·322 |

* Sky one-third or less covered at the hours of observation.

A COMPARISON *of some of the Meteorological Phenomena of* FEBRUARY, 1868, *with those of* FEBRUARY, 1867, *and of the same month for* SEVENTEEN *years, at Philadelphia, Pa.* Barometer 60 feet above mean tide in the Delaware River. Latitude 39° 57½′ N.; Longitude 75° 11¼′ W. from Greenwich. By PROF. J. A. KIRKPATRICK, of the Central High School.

| | February, 1868. | February, 1867. | February, for 17 years |
|---|---|---|---|
| Thermometer—Highest—degree | 52·00 | 55·00 | 70·00 |
| " date | 20th. | 14th. | 23d, '60. |
| Warmest day—mean | 42·67 | 51·83 | 59·30 |
| " " date | 21st. | 14th. | 27th, '57. |
| Lowest—degree | 3·00 | 16·50 | —1·00 |
| " date | 23d. | 11th. | 7th '55; 8th '61. |
| Coldest day—mean | 12·83 | 24·33 | 4·50 |
| " " date | 23d. | 10th. | 6th, '55. |
| Mean daily oscillation | 16·00 | 14·64 | 13·61 |
| " " range | 7·84 | 6·43 | 7·21 |
| Means at 7 A. M | 21·72 | 35·84 | 29·32 |
| " 2 P. M | 31·21 | 43·36 | 38·30 |
| " 9 P. M | 26·72 | 40·66 | 33·61 |
| " for the month | 26·55 | 39·95 | 33·74 |
| Barometer—Highest—inches | 30·748 | 30·970 | 30·970 |
| " date | 1st. | 11th. | 11th, '67. |
| Greatest mean daily pressure | 30·672 | 30·862 | 30·862 |
| " " " date | 23d. | 11th. | 11th, '67. |
| Lowest—inches | 29·566 | 29·303 | 29·045 |
| " date | 6th. | 3d. | 23d, '53. |
| Least mean daily pressure | 29·633 | 29·398 | 29·227 |
| " " " date | 28th. | 3d. | 16th, '56. |
| Mean daily range | 0·278 | 0·279 | 0·228 |
| Means at 7 A. M | 30·197 | 30·087 | 29·950 |
| " 2 P. M | 30·154 | 30·053 | 29·903 |
| " 9 P. M | 30·156 | 30·065 | 29·932 |
| " for the month | 30·169 | 30·068 | 29·928 |
| Force of Vapor—Greatest—inches | 0·231 | 0·361 | 0·549 |
| " date | 21st. | 14th. | 16th, '57. |
| Least—inches | ·038 | ·049 | ·013 |
| " date | 23d | 10th. | 6th, '55. |
| Means at 7 A. M | ·100 | ·171 | ·138 |
| " 2 P. M | ·121 | ·174 | ·157 |
| " 9 P. M | ·121 | ·193 | ·157 |
| " for the month | ·114 | ·179 | ·151 |
| Relative Humidity—Greatest—per cent. | 95·0 | 95·0 | 100·0 |
| " date | 27th. | 2d & 20th. | Often. |
| Least—per cent | 42·0 | 27·0 | 20·0 |
| " date | 19th. | 27th. | 22, '64. |
| Means at 7 A. M | 80·0 | 76·8 | 78·5 |
| " 2 P. M | 67·1 | 60·2 | 63·5 |
| " 9 P. M | 79·5 | 72·7 | 75·1 |
| " for the month | 75·6 | 69·9 | 72·4 |
| Clouds—Number of clear days* | 11· | 6· | 8·5 |
| " cloudy days | 18· | 22· | 19·7 |
| Means of sky covered at 7 A. M | 64·5 per ct | 65·3 per ct | 60·9 per ct |
| " " " 2 P. M | 50·7 | 68·2 | 60·6 |
| " " " 9 P. M | 47·9 | 61·4 | 48·5 |
| " " for the month | 54·4 | 64·9 | 56·7 |
| Rain and melted snow—Amount—inches | 2·59 | 4·820 | 3·237 |
| No. of days on which rain or snow fell | 6· | 12· | 9·6 |
| Prevailing Winds—Times in 1000 | N77°48′W·240 | N73°30′W·181 | N75°47′W·27 |

* Sky one-third or less covered at the hours of observation.

A COMPARISON *of some of the Meteorological Phenomena of the* WINTER *of* 1867–68, *with that of* 1866–67, *and of the same Season for* SEVENTEEN *years, at Philadelphia, Pa.* Barometer 60 feet above mean tide in the Delaware River. Latitude 39° 57½′ N.; Longitude 75° 11¼′ W. from Greenwich. By J. A. KIRKPATRICK, of the Central High School.

| | Winter, 1867–'68. | Winter, 1866–'67. | Winter, for 17 years. |
|---|---|---|---|
| Thermometer—Highest—degree | 52 50 | 61·00 | 71·00 |
| " date | Dec. 27. | Dec. 8. | Dec. 2, '59. |
| Warmest day—mean | 47 33 | 57·00 | 62·80 |
| " " date | Dec. 28. | Dec. 8. | Dec. 19, '56 |
| Lowest—degree | 3·00 | 6·00 | —9·00 |
| " date | Feb. 23. | Dec 21. | Jan. 8, '66. |
| Coldest day—mean | 12·83 | 15·33 | —1·00 |
| " " date | Feb. 23. | Dec 21. | F.7'55; F8'61 |
| Mean daily oscillation | 13·21 | 12 45 | 12 55 |
| " " range | 6 60 | 6·10 | 6·71 |
| Means at 7 A. M. | 26·27 | 30·27 | 29 56 |
| " 2 P. M | 32·86 | 36 61 | 37 29 |
| " 9 P. M. | 29·45 | 33·69 | 32·97 |
| " for the Winter | 29·53 | 33·52 | 33·27 |
| Barometer—Highest—inches | 30·748 | 30·970 | 30·970 |
| " date | Feb. 1. | Feb. 11. | Feb. 11, '67. |
| Greatest mean daily pressure | 30·672 | 30·862 | 30·862 |
| " " " date | Feb. 23. | Feb. 11. | Feb. 11, '67. |
| Lowest—inches | 29·291 | 29·303 | 28·941 |
| " date | Jan. 1st. | Feb. 3. | Jan. 23, '53. |
| Least mean daily pressure | 29·450 | 29·398 | 29 086 |
| " " " date | Jan. 1st. | Feb. 3. | Jan. 23, '53. |
| Mean daily range | 0·268 | 0.240 | 0·222 |
| Means at 7 A M. | 30·0 2 | 29 985 | 29 955 |
| " 2 P. M. | 30·056 | 29·948 | 29 912 |
| " 9 P. M. | 30·072 | 29·973 | 29 942 |
| " for the year | 30 070 | 29·969 | 29·936 |
| Force of Vapor—Greatest—inches | 0·361 | 0·472 | 0 551 |
| " date | Dec. 17. | Dec. 8. | Dec. 2, '59 |
| Least—inches | ·038 | ·042 | ·013 |
| " date | Feb. 23. | Dec. 20 Jan 30 | Feb. 6, '55. |
| Means at 7 A. M. | ·121 | ·141 | ·138 |
| " 2 P. M | ·126 | ·145 | ·156 |
| " 9 P. M. | ·134 | ·153 | ·152 |
| " for the Winter | ·127 | ·146 | ·149 |
| Relative Humidity—Greatest—per cent. | 95·0 p. c. | 96·0 | 100·0 |
| " date | Jan 31; F. 27 | Dec. 16. | Often. |
| Least—per cent. | 30·0 | 27·0 | 20·0 |
| " date | Jan. 24· | Feb. 27. | Feb. 22, 64. |
| Means at 7 A. M. | 79·7 | 77·5 | 78·5 |
| " 2 P. M. | 65·6 | 63·7 | 65·2 |
| " 9 P. M | 78·1 | 72·8 | 75·5 |
| " for the Winter. | 74 5 | 71·3 | 73·1 |
| Clouds—Number of clear days* | 25· | 32. | 26·1 |
| " cloudy days. | 66· | 58· | 64·1 |
| Means of sky covered at 7 A. M. | 65·0 p. c. | 54·9 p. c. | 62·4 p. c. |
| " " " 2 P. M. | 60·5 | 61·5 | 62·2 |
| " " " 9 P. M. | 50 9 | 49·0 | 48 8 |
| " " " for the Winter | 58 8 | 55·1 | 57 8 |
| Rain and melted snow—Amount—inches | 8·94 | 10·267 | 10·178 |
| No. of days on which rain or snow fell | 31· | 29· | 30·9 |
| Prevailing Winds—Times in 1000 | N 72°3′ W. 235 | N 78°9′ W. 313 | N 66°51′ W. 287 |

* Sky one-third or less covered at the hours of observation.

# JOURNAL
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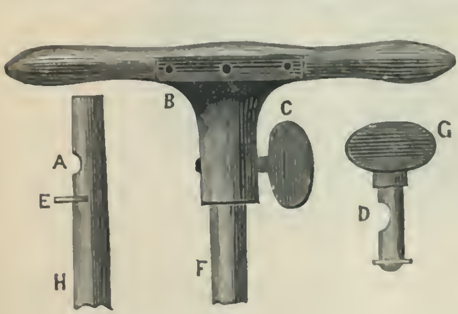
PROMOTION OF THE MECHANIC ARTS.

Vol. LV.] APRIL, 1868. [No. 4.

## EDITORIAL.

### ITEMS AND NOVELTIES.

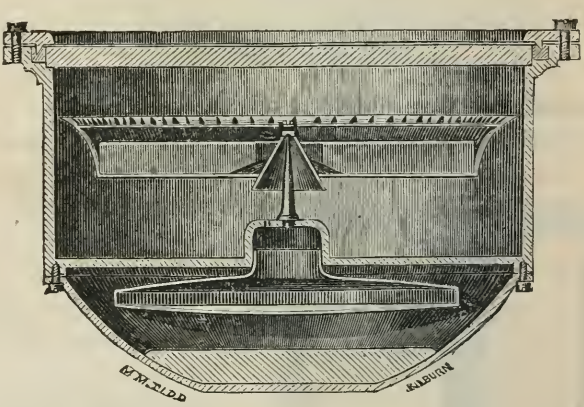
**Brace and Bit Connection.**—We give herewith a cut, showing the details of a simple and effective arrangement for the above purpose, devised by E. Haskell, of this city, and not patented.



In the middle of the cut is shown the handle of the brace, with its metal socket B, the shaft of the bit or auger, F, and the pin, E, by which the attachment is secured all in their places as when in use. At one side, we have the securing pin, G D, and on the other the shaft of the bit, A H, removed from the socket of the brace. The shaft of the bit is slightly tapered to fit a corresponding cavity in the brace, and has also a pin, E, which fitting a corresponding notch in the brace, determines its position when introduced, and a cavity or hollow, A, corresponding with the diameter of the pin, D. The pin has also a hollow, corresponding with the shaft of the bit, and is fitted into the socket of the brace, to one side of its axis, so that when the hollow of the pin is toward the axis, there is a free passage for the shaft of the bit. When, however, the pin is revolved in the corresponding hollow of the bit, it receives it in place. A pin running through the end of this pin, serves both to hold it in place, and by bearing against a projection on the outside of the socket, serves to indicate the position when the pin is so adjusted as to admit or release the bit.

**The Liquid Compass,** of Mr. N. S. Ritchie. This instrument is designed to avoid the evident and serious derangement which the ordinary compass suffers, when exposed to sudden movements, changes of motions or shocks, such as will constantly occur at sea, from the pitching or rolling of the vessel, or the irregular action of machinery in the case of a steamer.

We do not here mention this instrument as a *new* thing, but rather as an invention which, in addition to its merit of ingenuity, has the additional claim to our attention, that it has stood the test of practical use, and has been fully approved by practical experience.



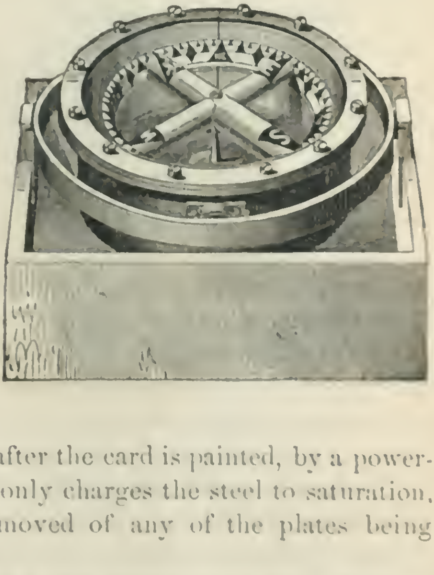
While the apparatus is well known among those most concerned (some 2000 of these compasses being in use already on vessels of all classes in the merchant service, independent of war ships), and while its efficiency, as this fact alone shows, is fully established and recognized, no description has ever been published by which those interested in scientific subjects, and the world at large, can obtain information with regard to its structure and principle.

We therefore regard the space needed for a description of this instrument, as most judiciously applied when devoted to that subject.

The bowl is made of brass, with glass top made perfectly tight by means of a rubber band.

Beneath the bottom of the bowl, and within a convex cover, is a thin, metallic elastic bag, capable of holding twice the amount of expansion for change of temperature from 0° to 100; this bag opens into the bowl, and is soldered to it. When the compass is filled, the liquid is placed under the receiver of an air-pump, and most of the air contained in the liquid is drawn out to prevent possibility of any bubbles. The card is made of two or more cylinders of very thin tinned brass; the usual form is that of two such cylinders, placed at right angles to each other, one of which contains the magnetic needles; a ring of thin brass of the form shown in the cut, surrounds these cylinders, and closes the ends. A cone for the agate cap is placed in the middle.

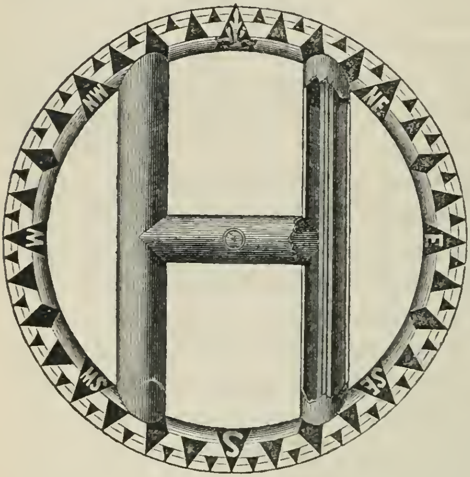
The closed cylinders are thus made air-tight, and form buoyant air-vessels; the size is made so that the volume of water displaced, is a little greater than the entire weight of the whole, including the needles; small pieces of lead are attached below, which are cut so as to bring the weight to the desired amount over that of the liquid.



The needles are made of thin steel, of six or more sheets lying side by side, placed with their edges up and down; they are bent in the middle so as to go round the cone, as shown in the cuts.

The needles are magnetized after the card is painted, by a powerful electro-magnet, which not only charges the steel to saturation, but the possibility is thus removed of any of the plates being wrongly charged.

In some cases, the needles are enclosed in two parallel cylinders, at 60° distant, and, to gain a greater amount of buoyancy, and also to reduce the size of the cylinders, the outer ring is made hollow. In the smallest boat compasses, only one cylinder is used, and the hollow ring retained.



In all, the needles are placed below the centre of the cylinders, so that the centre of gravity of the whole is below the centre of the mass, or centre of buoyancy; by this means, although the whole may bear little or not at all upon the pivot, yet the ring will retain its horizontal position, and if displaced quickly, return to it.

The cards are weighted so as to sink in *all temperatures;* this makes the card rest upon the pivot with a pressure of from 20 to 80 grains; the medium size 8-inch card at 60°, bears with a weight of about 50 grains, or about 3 grammes. This slight pressure is enough to retain the card centrally in the bowl.

The friction is thus reduced to the amount that this pressure of 3 grammes can produce, and the force that can be exerted by any blow which the compass can receive, or by the motion of the vessel, which must be resisted by the pivot, can only be that equal to the inertia of the 3 grammes.

The compass has been subjected to a fall of ten feet and more, and yet the sensitiveness not diminished.

In the larger sizes, to prevent any effect from the vibration of the bottom and the glass (which at the maximum may be $\frac{1}{50}$th inch), the pivot is a rod movable in a tube, with a spring capable of bearing 200 grains, and has a range of $\frac{1}{20}$th of an inch. The firing of a gun or a violent blow, may bring this into play.

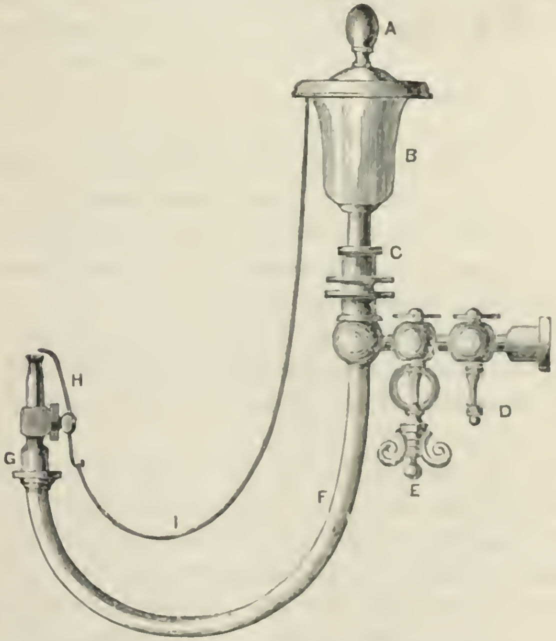
The inertia of the liquid, and the very slight friction of the sides and bottom of the bowl, prevents it receiving any perceptible motion by any change in the direction of the vessel, (this can be shown by throwing some paper chips into a tumbler of water and turning it round) and oscillation of the needle in the roughest sea is impossible, yet it opposes no resistance to the needle's obeying the polar force.

After years of constant use, there is no perceptible wear to the pivot.

**Electric Gas Lighters.**—One of the most useful and successful applications of statical electricity ever made, indeed we may fairly say, *the most* useful, is found in the various forms of apparatus devised by Mr. Robert Cornelius, of this city, for the above purpose.

In the accompanying cut, we illustrate one of the most usual forms.

In the first place, there is a bracket of the usual sort, except that it is provided with two stop-cocks, one with a small handle, D, which is used simply for adjustment, so that the gas may not come through with too great violence when the other is turned full on.



Upon the upper part of this bracket is fixed, by an insulating piece, C, made of hard rubber, a brass vase, B, lined internally with silk. Within this vase fits a plug of hard rubber, with a metallic cap and knob, A. From the metallic vase, B, runs a wire, I, terminating in a platinum point, H, which is sustained at the side of the burner by an insulating support.

When the plug of vulcanite is inserted in the vase and slightly moved about, electricity is excited by friction, a negative charge being acquired by the vulcanite and a positive charge held by induction to the inner surface of the brass vase. This charge is, however, entirely fixed to the inner surface of the vase by the attraction of the negative surface of the vulcanite, and does not tend to escape, even though the brass cap of the plug, A, touches the rim of the vase, and thus makes, through the hand, a connection with the ground. When, however, the plug is withdrawn, the charge in the vase is liberated and passes, by the only circuit then open, through the wire, I, by a spark into the burner, and so to the ground.

After the vulcanite has been once charged, it is no longer necessary to produce any friction, merely replacing it in the vase will cause an induced charge to collect in the vase, positive fluid being drawn from the hand through the brass cap then in contact with the edge of the vase.

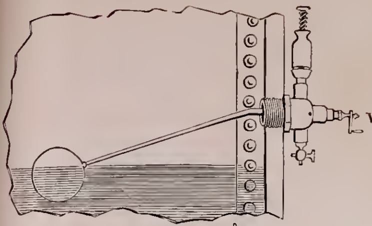
With regard to the efficiency and reliability of this apparatus, we can speak both from experience and report. In one of the lecture-rooms at the University of Pennsylvania, the burners are provided with these attachments, and during the past year, summer and winter, we have been constantly in the habit of entering in the dark and securing a light without fail, by this means.

Several of our friends have, for many years, employed the same apparatus with a like result, and unite in the opinion that, with any reasonable amount of care and judgment in its management, it is eminently reliable and convenient.

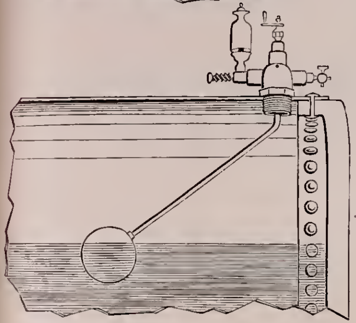
The same principle has been applied by Mr. Cornelius in the construction of electric lightning wands, and other forms of the apparatus, exhibiting great ingenuity, and also thoroughly effective.

**An Improved Low Water Detector** and Alarm, the invention of, and patented by, John Cosfeldt, of Philadelphia, June 13, 1865.

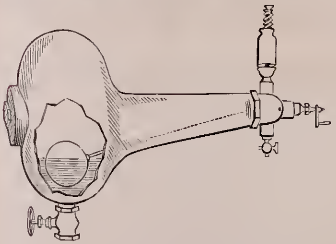
This instrument is composed of a chamber, screwing into the head or the top of the boiler, into which from the inside of boiler is introduced a lever, to which a float is attached, operating on a valve in said chamber as the water recedes, causing an opening for passage of steam to blow the whistle. This valve is operated simply by leverage. The instrument is in all its parts non-corrosible, and not liable to get out of order. In applying it to the boiler, the attachment is made in *dry steam*, and not below water.



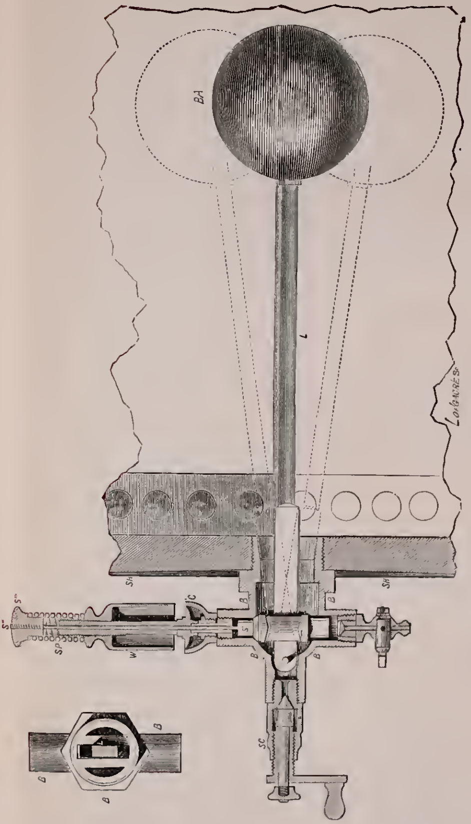
No. 1 Style.
Working in Head of
boiler.



No. 2 Style.
Working on Top of
boiler.



No. 3 Style.
Cast Iron Chamber
with Detector working inside.



THE COSFELDT PATENT LOW WATER DETECTOR.

For boilers where it is inconvenient or impossible to apply the detector in this form, there is another style, viz: a cast iron chamber to be attached externally, in which the detector operates.

A model boiler, with detector working, can be seen at the office of the Cosfeldt Patent Low Water Detector Company, of Pennsylvania, No. 132 South Third Street, Philadelphia.

**Skeleton Grate Bar.**—[We have received the following account of this apparatus from one well acquainted with its use, accompanied by a weighty mass of testimony.—Ed.]

Figure 1 shows a longitudinal, and Fig. 2 a transverse section of the Skeleton Grate Bar. The column of cold air passes up both sides or surfaces of the bar, at the same time through the longitudinal opening, A, as shown at the bottom of the cut, then passing out at the side holes, B, performs the double purpose of cooling the bar, and evenly distributing the air.

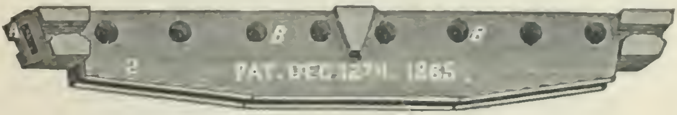


Fig. 1.

Many patents have been granted for alleged improvements in bars for furnaces. These changes of pattern appear to have been designed more to please the eye than to effect any useful object.

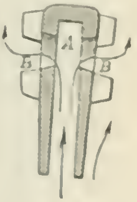


Fig. 2.

The Skeleton Bar, while preserving the general external form of ordinary bars, are made with special regard to the scientific principles of combustion.

1st. A positive and radical improvement has been introduced. It consists of the channel (as shown in the engravings) running the whole length of the interior of the bar, in connection with the holes at the sides.

2d. Durability.—The trough-like form is calculated to resist warping or twisting; while the rapid and constantly changing current of air through the heart of the bar, tends to preserve it from the effects of the fire.

3d. Better combustion and consequent economy of fuel.—The vitality of fire depends as much upon the oxygen derived from the air, as upon the carbon or bitumen of the fuel used. Scientific and practical men have long been aware that the supply of air through the interstices of grate bars has been lamentably deficient, and a serious waste of fuel the result. The peculiar construction of the Skeleton Grate Bar allows of the passage of a much greater volume of air than is permitted to pass by bars of the ordinary sort, of the same cross-section and distance apart.

The free access of air is useful in several ways. It lowers the temperature of the bar.

It enables the use of a smaller size of coal, reducing the cost per ton for fuel.

As the heating power of fuel is derived from the combination of its elements with oxygen, which oxygen is obtained from the air, it is of the greatest importance to secure a full supply of air.

Perfectly burned carbon produces carbonic acid, that which is burned with an insufficient supply of air forms carbonic oxide, which gas passing off by the chimney, is the source of great waste of fuel. To ensure perfect combustion, that portion of the air which is required to pass through the fuel, should be as thoroughly distributed over the whole grate surface as is possible.

If the spaces between the grate bars are not free and open, the air enters with large volume at a few points, causing great heat in those localities, and favoring the formation of clinker, and even melting the bars; and on the other hand, if the grate bars be not equally and well covered, the air will enter and pass those parts more thinly covered, where it is least wanted, and where it should be most limited in amount.

The Skeleton Grate Bar allows the use of a greater depth of fuel than the ordinary bar, and thus gives greater security that the bars be fully covered, and not liable to the above objection. The importance of furnishing a suitable supply of air to convert all of the carbon of the fuel into carbonic acid, in order to obtain the most economical result, is very readily shown.

In the conversion of one part of solid carbon into carbonic oxide, there are involved 2,473 heat units. In the conversion of the carbonic oxide thus obtained, into carbonic acid, there are involved 5,607 heat units, making 8,080 heat units in all, of which the first or imperfect combustion yielded but thirty-one per cent. of the obtainable heat; so that to limit the supply of air so as to cause the exclusive production of carbonic oxide, would necessitate the use of three times as much fuel as would be required to do the same work were it properly burned. The perfect combustion of one ton of anthracite coal or of coke, requires over 5,970 pounds of oxygen, derived from about 340,000 cubic feet of air at ordinary temperature, equivalent to a column one foot square and over sixty four miles in length. This calculation is based upon the supposition that all of the oxygen of the air is made available, but in practice it is found necessary to introduce twice the quantity of air that by calculation would be sufficient.

Another result of the ability to introduce a larger amount of air with the same force of draft, is that of using fuel of a smaller and cheaper sort. If we suppose the fuel to consist of cubes, four inches on each side, we should have twenty-seven such pieces to the cubic foot, with an aggregate surface of 2,592 square inches, requiring a fixed amount of air per minute for its proper combustion. If, now, in place of the four-inch cubes, we substitute others of one inch on each side, we will have 1,728 to the cubic foot, and a total surface of 10,368 square inches, or four times as great a surface exposed to fire contact. Consequently, to obtain the same intensity of combustion, there will be required four times as much air in the same time to burn the small fuel, as will be required for the larger fuel, or else we must diminish the thickness of the layer of fuel upon the bars, so that in burning the smaller coal it shall be but one-quarter the depth of that employed in burning the coarser sort.

The adoption of the Skeleton fire bar affords a valuable aid in securing perfect combustion and economy in the use of fuel, from its ability to allow of the passage of a larger volume of well distributed air, than is done by the bars in ordinary use.

Smith & Ellis, sole manufacturers in Philadelphia. Foundry—York and Moyer Streets. Office—35½ South Front Street.

Office of the Company, 501 Commerce Street, Philadelphia. John McCartney, President, Jos. S. Fisher, Treasurer and Secretary.

**Ozone.**—(A new experiment, illustrating its peculiar property of energetic affinity). Our attention was drawn to the above subject, by a very youthful physicist, Master Chas. J. Gibbons, who was led to the observation in the following manner: He was provided with one of those judicious collections of chemicals and apparatus packed in a small box, known as Crew's Laboratories; and among other experiments possible therewith, was trying the development of ozone, by the action of a heated glass rod upon a mixture of air and ether, only that he had varied the experiment by substituting oxygen for air and a glass tube for a rod. Under these conditions, a tremendous detonation was the result of the introduction of the heated tube into the mixture. Nothing daunted, however, by this at the least, startling phenomena, he repeated the experiment, supposing that perhaps the glass might have been too hot, but again—with a tube that could be drawn through the closed hand without burning, the explosion followed as before. A glass rod was then tried, but produced no such result, even when at a low red heat.

The conclusion was obvious. The portion of mixed gas and vapor inside the tube, being confined, was so completely acted upon, that ozone in sufficient purity and bulk to ignite the vapor or mixture was produced; while in the case of the rod, that part of the oxygen converted into ozone at each instant, was too rapidly diffused and diluted for such a result.

**A New Galvanic Battery** is described in the last number of "*Les Mondes*" as follows: M. Boéttger has published in a recent article a mode of constructing voltaic batteries, which has the advantage of being simple and of small expense. It is particularly applicable where a constant current is desired; as for example, for electric clocks. It consists of a jar of glass or earthenware, into which is introduced a hollow cylinder of zinc, containing a cylinder of coke. These two cylinders do not touch, and the space between the two is filled with a mixture of common salt and sulphate of magnesia in a moist condition.

The cells or elements are then connected in the ordinary manner.

**A New Thermometer,** which is not affected by radiation, has lately been devised by Dr. Joulé.

It consists of a copper tube surrounding another tube, which is open at the top, and having a hinged bottom; in the smaller tube is suspended a fine wire in a spiral form, suspended by a silk thread, upon which is a small mirror. When the bottom is closed, the mirror stands at 0°, but when open, the air inside being usually warmer than the outside atmosphere, a current is established, twisting the silk. One degree Fahrenheit, causes a complete turn of the mirror. The cause assigned by the author for this elevation of temperature inside the copper tube, is, that the copper absorbs light and heat from the atmosphere, and causes an internal radiation.

# Editorial Correspondence.

## RAILROAD NOTES.

New York, *March*, 1868.

Considering the general depression hanging over the country, the railroad interest is remarkably active, and indeed since railroading was first started, I do not think there ever was such activity as at the present time in this important department of internal improvement. This is certainly true of the country in and around New York, which point seems to be the *ultimathule* of almost every railway in the country, in some way, directly or indirectly. The following notes embody a synopsis of the numerous projects in all stages of development, in what may be called the vicinity of the metropolis.

*The Boston, Hartford, Erie Railroad* is intended to bisect the State of Connecticut as near as may be, and striking the Hudson River at Fishkill, there connect with the Newburg branch of the Erie road. There are eleven north and south roads bisected in its course: all important business connections. This road has not a very straight alignment, as will be noticed by tracing its course eastward from Fishkill, through Danbury, Waterbury, Hartford, Willimantic, Mechanicsville, Blackstone to Boston, a distance in all of some 220 miles. The surveys show the curves to be comparatively light, with a maximum grade ascending east of 60 feet per mile, while that of the ascending western grade is 66 feet. The highest summit is 763 feet, and lies in the range of hills between the Hudson and the Harlem Railroads. A goodly portion of this line is already completed, and the authorization of the Massachusetts Legislature for a $3,000,000 loan, with as much more in bonds guaranteed by the Erie Railway Company, seem to promise an early opening over the whole route. The estimates are published at $45,000 per mile, and the projectors are sanguine of a great and increasing traffic.

*The Erie and New England Railroad* is designed to connect "Turner's" on the Erie Railroad, with Derby, Connecticut, in a nearly due east alignment. This road will be 60 miles long, 22 of which are in Connecticut. To be graded to accommodate both the narrow and wide gauge, and is intended to cross the Hudson at or near Peekskill, over the "Highland Suspension Bridge," which, by the way, is blocked out, as below, by Gen. Edward Serrell, of "New York Engineer Regiment" fame, whatever that was. Clear span, 1600 feet. Total length, including approaches, 2,499 feet; elevation above high water, 155; height of towers above high water, 280 feet; with several thousand miles of steel wire in the cables, which are to be in four systems, each cable being 14 inches in diameter. To carry safely 35,000 people and 60 locomotives.

*The Spuyten Duyvel Railroad* is intended to connect Commodore Vanderbilt's two roads, the Hudson and Harlem, and will be begun this Spring. It is an important link of about five miles, and is estimated at $50,000 per mile.

*New York Housatonic and Northern Railroad* is a short line of 40 miles, and leaves the Harlem Road near White Plains, and runs northward through North Castle, Bedford, and Cross River; thence through North Salem, Ridgeberry, and striking the Housatonic line at Brookfield. The Engineer reports 70 per cent. of the route straight, the minimum curvature 1146 feet, and the maximum grade 60 feet to the mile. The estimate for business places "milk" about 50 per cent. of the whole, so that it will be essentially an "iron tailed cow." The whole line is under contract, and expected to be finished in a year from now.

*The Dutchess and Columbia Railroad* starts from Fishkill, on the Hudson, running through the counties from which it takes its name, to a point on the Harlem road, a total distance of 63 miles. This is a very inexpensive line to construct, and is now under contract. Two-thirds of the line is straight, the maximum grade being 53 feet, and but two unimportant bridges occur in its whole length. It occupies a good location for business, and promises to be remunerative.

*The Western Connecticut Railroad*, is a proposed route from Springfield, south-west through Granby, at which point they tap the Salisbury iron mines; thence to New Hartford and Winsted. It comes over into New York, striking the Harlem road at Amenia, and finally joins the Dutchess and Columbia road near Washington Hollow. The grade is reported to be the best as yet surveyed between Long Island Sound and the lakes, for an east and west road, with but one instance of the grade exceeding 60 feet, and that is for about three miles on the eastern side, where it is 80 feet to the mile. The curves are remarkably easy, and the grading unusually light.

*New Haven and Derby Railroad* is a short line of but 10 miles, and is of course designed principally for local accommodation. It is now being graded with expectations of being finished the coming fall. There is a considerable amount of grading on the line, especially that portion passing over an ugly marsh, which it does for over a mile, and over which the grade is carried on piles.

*The New Haven, Middleton and Willimantic Road*, is located to connect New Haven and Willimantic, which latter point forms one of the links in the chain of the Boston, Hartford and Erie line. The line is 51 miles long, and is to be laid with steel rails, laid with the Smith or Hudson River joint. As the intention is to make this road part of an air-line, between New York and Boston, the plant and fixed constructions will be of the most durable character, and in which no expense will be spared to make them what they should be. A large and important bridge-crossing will be necessitated by the Connecticut River, and the original intention was to construct a suspension bridge of 900 feet span, high enough above high water as not to impede navigation. The Legislature of Connecticut has been petitioned to allow of a low grade bridge, with a draw presenting water-ways of 125 feet. This has not been granted, and is hardly possible this session.

*The Midland Railroad* is intended to shorten the distance from New York to the lakes, avoiding the circuitous Erie and Central roads. As the intention is to build this line by communities, that is by towns subscribing in their corporate capacity, and not by individuals, some time was required to locate a direct line and satisfy those villages and towns that subscribed to the stock. In general direction, it bisects the region of country between the Erie and New York Central roads. The eastern terminus will probably be at Hoboken, on Mr. Stevens' property. Probably the coming six months will see the whole line under contract. The country traversed is a rolling one, but the maximum grade has been limited to 65 feet to the mile, as this line when completed will form an important route to the West, saving at least two hours over the Erie road. A connection is contemplated with the Highland Bridge, for a Boston outlet.

*The Hudson River West Shore* line occupies the ground indicated in its name, connecting at Athens with the already built and operated Athens road, and will form an important rival to the Hudson River Road. The General Government has given the right of way through the West Point property, and the Company has bought the Northern Railroad for their southern link to Jersey City, which leaves but a moderate amount of new road to construct.

*The New Canaan Railroad* will run from Stamford, Connecticut, on the New York and New Haven Railroad, northward to the village of Canaan. This road is only eight miles long, with very light work, and the grading is now ready for the iron.

*The Lebanon Springs Railroad* was commenced in 1863, and after $300,000 had been expended, work was discontinued. Operations were resumed some time since, and now more than half the road is ready for the iron. This road really forms an extension of the Harlem from Chatham-Four-Corners, to Bennington, Vermont, where it connects with the Rutland and Bennington Railroad. When completed, there will be an air-line between Montreal and New York, and there is every probability of this being an accomplished fact the coming summer. The distance traversed by this Lebanon Springs Road is 54 miles, in a nearly straight alignment, the longest bridge being but 200 feet.

*Kinderhook and Neverville Railroad*, is designed to connect Hudson, on the Hudson River Road, to Neverville, on the Boston and Albany Road, a distance of 16 miles, and is expected to be built for $500,000. Short as the line is, it traverses a fertile country, and promises to be a paying investment.

*The Walkill Valley Railroad*, is a continuation of the Montgomery and Erie Railway (which leaves the Erie road at Goshen). It is a broad guage road of 12½ miles, and will eventually be extended to Kingston, where it will connect with the Rondout and Oswego roads.

*The Goshen and Deckerton Railroad*, is the northern continuation of the above Walkill Valley road. The intention is to run from Goshen to the State line of New Jersey, some 13 miles. Here the extension of the Sussex and Branchville road will be met, which will enable coal to be sent from Pennsylvania mines into Orange County, without breaking bulk.

*The Vernon Railroad* now being operated as a feeder to the Morris and Essex road at Waterloo, is to be extended northward to Franklin, 12 miles; thence, by Hamburg and Vernon, to Warwick, when connection will be made with Warwick and Newburg branches of the Erie Railroad for other eastern ramifications, distributing Pennsylvania anthracite coal vastly cheaper than can be afforded by the present lines of traffic. It is in fact an air-line link to west and south-west from the Eastern States, and of which the Lehigh roads form part.

*New York and Newark Railroad* is intended for local accommodation merely between those cities, and is located in a straight line from one end to the other, being at least seven per cent. shorter than any of the existing lines. It is in the hands of the New Jersey Central Company, and strikes their ferry at Communipaw. In such a line, it has unusual obstacles to overcome, in the crossings of the Passaic and Hackensack rivers, as well as a long, deep trap-rock, cut through Bergen Hill, of the same character as that through which the Erie tunnel was pierced; which, by the way, afforded singularly fine specimens of certain zeolite minerals. Rapid and light trains at intervals of fifteen or twenty minutes, are expected to attract a large proportion of the travel to and from Newark. The river bridges will both have "draws" in the channels, of the "Mosely arched rib pattern," slung with hog chains from standards. The balance of these bridges will consist of piling. Maximum grade allowed is 21 feet, on account of the character of the proposed plan of operating, noted above.

*The Patterson and Newark Railroad* runs up the Passaic Valley from Newark, connecting with Erie road at Patterson, and will be of considerable advantage to New Jersey manufacturers in shipments of Western freights, saving the expense and trouble of shipping to New York, and those making transhipments.

*The Vineland Railway* is a projected line of 60 miles, to open up the rich trucking districts of southern Jersey to the New York markets, via the Pemberton and Hightstown Railroad. Its alignment and connections guarantee a large freight and passenger traffic.

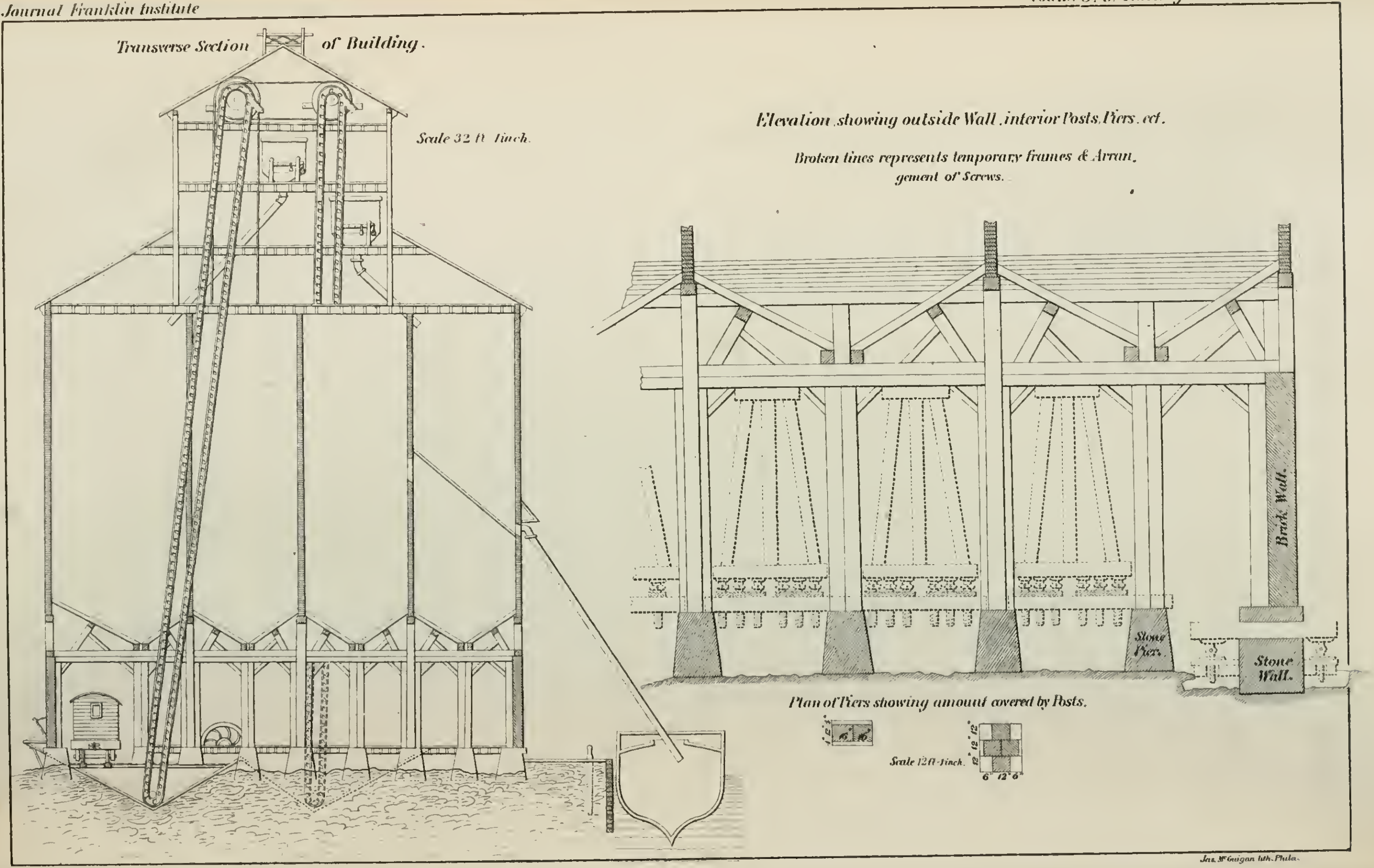
*The Monmouth County Agricultural Railroad* will connect Freehold, New Jersey, with Keyport, on the Raritan Bay, a distance of 14 miles, and is estimated at $15,000 per mile.

*The Rondout and Oswego Railroad* is composed of numerous links of already existing lines, together with 95 miles of new road to be built from Colliersville, on the Albany and Susquehanna road, to Rondout, on the Hudson, making a total distance between the objective points of some 221 miles. But 73 miles of the Eastern division are definitely located, and with the exception of the Catskill Mountain crossing, the grades are very favorable. On the mountain division, a tunnel of 1600 feet will be required. The estimate averages $40,000 per mile.

In conclusion, I send a memorandum of the New Jersey Pneumatic Transportation Company.

*The New Jersey Pneumatic Transportation Company.*—Although the mode of transportation designed to be employed by this Company does not exactly belong to the same class as railroads, it nevertheless seeks to obtain the same results as locomotive roads, and differs from them in principle only in the motive power. The subject of moving valuables, light freights, parcels, and mail matter at a higher rate of speed than can be attained by any of the methods now in use, in this country, had long occupied the minds of engineers and others, when in May, 1867, the Company above mentioned was incorporated, and received a charter from the State of New Jersey. The franchise gives them the exclusive privilege of laying pneumatic pipes in that State, fixes the capital stock at $500,000, and requires that at least ten miles of pipes shall be constructed within three years. The Company proposes to lay part of the required ten miles from Jersey City to Newark, along the line of one of the railroads now in operation between those points. The tube is to be of wood and three feet in diameter, but the details as to carriages, engines, and so forth, have not yet been decided upon. It is expected to be able to transport articles at as high a speed as one hundred and fifty miles an hour, and to have perfect control over the carriages, stopping them at pleasure and at any place. The pipes may be laid in curves, and over grades, and can be constructed for $30,000 a mile. After the success of the enterprise is practically demonstrated, the Company proposes to lay tubes to Washington, and thus secure the carrying of mails from that city to New York, and also of money parcels and other small packages. In this connection, it may be proper to mention that a Company has just been organized, styled the New York, Jersey City and Brooklyn Pneumatic Transit Company. The design is to lay pipes from Brooklyn, under the East River, through New York and under the North River to Jersey City. The tube in this case is to be six feet in diameter, with the intention of transporting passengers as well as freight. Whether the greater rapidity and saving of time by this means would induce people to prefer it to the ferries, is a matter yet to be determined. The project is now before the Legislature for a charter.

A. P. B.



Transverse Section of Building.

Scale 32 ft. 1 inch.

Elevation showing outside Wall, interior Posts, Piers, ect.

Broken lines represents temporary frames & Arrangement of Screws.

Plan of Piers showing amount covered by Posts.

Scale 12 ft. 1 inch.

Jas. McGuigan lith. Phila.

# Civil and Mechanical Engineering.

## THE RAISING OF THE GREAT GRAIN ELEVATOR BUILDING, AT MILWAUKEE, WIS.

By D. J. Whittemore, CE.

This building, situated on the banks of the Menomonee River, at the eastern terminus of the Milwaukee and St. Paul Railway, in the city of Milwaukee, is the largest, and by many persons conceded, the most convenient building in the world devoted exclusively to the receiving, storing and shipping of grain.

Its capacity is 1,250,000 bushels. Size, 280 feet long, 86 feet wide, and 130 feet high.

To a certain extent, a description of its construction is necessary, to properly understand the remarks which follow:

The plan of the storage bins, consists of dividing the length of the building into twenty-eight equal spaces, and the width into four parts, by partitions, constructed in the usual manner, of two-inch plank lying flat-wise on and breaking joints with each other, thoroughly spiked together, and thus built up to a height of sixty-one feet.

In the interior of the building, this work rests on a frame of oak beams, supported by clusters of posts, alternating two and four posts in each cluster, every ten feet apart from centre to centre, throughout the entire interior. The posts are 12 × 16 inches in size, 15 feet long, and rest on stone piers, built up from a pile foundation. The first or business floor, is at the top of the stone piers, on which the posts rest. The next floor is at the top of bins 76 feet above first floor. The foundation of the outside wall is piled, on which a stone wall 4 feet thick and 5 feet high rests. On this is placed the water-table, and then a brick wall 20 inches thick, and 15 feet high, to the under side of the frame work, supporting the wall of the bins. That portion of the building above the bins is built of frame, 40 feet wide, 270 feet long, four stories high, and is used for machinery, distributing and weighing grain, &c.

Notwithstanding this building rests on 9000 piles, averaging 30 feet long, it began to settle soon after it was completed, in the beginning of the year 1865, and in the summer of 1867 was found to be so low, in several parts, as to preclude its being worked to its proper capacity, on account of many of the lower receiving hoppers being below the level of the water in the river. At this time, the greatest settlement at one point was $2\frac{17}{100}$ feet. It appeared that this settlement was not caused by the piles slipping through the earth into which they were driven, as the surface earth had the same relative height to the building as when it was constructed, but was owing to the compression of the substratum. This was rendered apparent by the alteration of the heights of the railway tracks in the vicinity. One of my "bench-marks," used as a datum in taking levels, situated on a pile driven 30 feet into the ground, and distant 100 feet from the building, opposite where it had settled the least, went down three-fourths of one inch in twenty-eight months, with no weight upon it.

Judging from borings, it is believed that the substratum in which this compression takes place, consists of peat, intermixed with a large proportion of sand.

On the 20th of June, 1867, it was decided to raise the building, and by the 27th all grain in store was removed from it, and work commenced inside and out. It may be well to state, that prior to the commencement of the work, the party in charge stipulated to have the same completed in season to accommodate the grain traffic of the year, which would commence on or about the 20th of August.

The first work done, was the laying inside and outside of the outer wall of the structure, a foundation of timber on the earth. Cutting through the four feet thick stone wall, directly under the water-table, and inserting beams twelve inches square and ten feet long, each end projecting on either side of the wall, over the foundation timbers before mentioned, between which and the beams, screws were inserted. These beams were put through the wall as near to each other as practicable, and resulted in placing the weight of the outside walls entitely upon the screws. This process was simple, compared with the arrangement necessary in the interior. At each cluster of posts, the stone piers had a top area only a little larger than that covered by the posts. In a majority of instances, the pier projected only from four to six inches outside of the posts. To secure an even foundation for screws, that perforce had to be some distance apart, to prevent, in measure, settling of foundation, bringing a great strain upon a small number of screws, and thereby crushing them, the plan was adopted of using these four and six-inch vacant parts of the pier tops, instead of the ground, as a foundation to work upon. To this end, timbers were laid across from pier to pier throughout, and bridged in a secure manner. On this the screws were placed. Between each cluster of posts, a frame was constructed of timber, 10 × 12 inches in size, consisting of three posts sill and caps resting on the screws, the posts extending from said sill to the under side of the beams, on which the structure above rested. The cluster of posts were made fast to the beams above, so that they would raise with the building. Levels had been taken on top of each pier to ascertain the proper height to raise, and thickness of pier caps to be introduced under posts.

When this height was less than one foot, cast iron cellular blocks were used. In all other cases, stone, in one piece of the requsite size. These were all provided, marked and numbered, each for its particular place beforehand. To provide, to a certain extent, for future settling of the structure, the rule was adopted to raise the building at all its parts one-quarter as much above the true plain of foundation, as such parts had settled below; that is to say, that where the subsidence was too feet, the rise should be $2 + \frac{2}{4} = 2\frac{1}{2}$ feet. It must be understood that the building had not settled equally throughout all its parts. The south end settled but little, while the greatest depression was confined to the middle, west side, and north end, causing a curve sideways in the line of the top of the building, having a versed-sine of twenty-eight inches. The building was constructed of green lumber and timber; it settled and seasoned in this crooked state.

As the partitions of the bins are generally eight inches thick, of plank, and sixty-one feet high, one every twenty feet longitudinally, and one every ten feet transversely throughout, it can be conceived that in raising and giving a new or rather reverse form to the plain of the old foundation, unequal resistance to the action of the screws would result. Such was the fact. Had each screw to exert an equal force, then about six tons would have been the power required of each of the sixteen hundred and fifty (1650) used in raising. When the work of raising commenced, it was soon demonstrated that a force of sometimes nine tons was required to each screw in some of the lowest parts of the building, while at the higher parts comparatively little force was required; in fact, it was necessary in many places to carry the building from four to six inches higher than intended, to be able to shove under the previously prepared pier caps on piers, twenty to forty feet distant. After all the screws were in place, the work of raising commenced, and after one week's labor, the structure was at the proper height to introduce the stone and iron pier caps. To do this, all timbers and screws had to be removed from the pier in hand. Other than that this process brought a great weight upon the adjoining screws, sometimes stripping them. No difficulty was encountered, of moment, in performing this portion of the work. This part done, the old floor was removed, and timber taken away that was used for the screw foundation, new floor laid at the right height, the fourteen iron hopper tanks raised to a proper height, screws and timbers removed from the outside walls, and the same bricked up under the water-table; seventy feet of the west brick wall which had crushed badly in settling, removed; shafting lined, scales leveled, and the whole building put in complete working order, on the stipulated day, the 20th of August, 1867, and in time for the fall business.

From over one thousand levels taken at different times, extending through a period of twenty-eight months, prior to the raising of the elevator, compared with an average load of 400,000 bushels of wheat, the monthly settlement was found to be ·05855 feet. The building has now been raised six months, and under a similar average load, shows a monthly settlement of ·03477 feet. So that it appears to have decreased from former monthly settlement, two-fifths nearly. There are strong grounds for believing that this monthly rate will rapidly decrease and soon vanish, rendering it unnecessary to raise the structure again.

The average number of men employed upon the work was one hundred and thirty.

**Engineers' Office, Milwaukee and St. Paul Railway Co., Milwaukee, Wis., Feb. 28th, 1868.**

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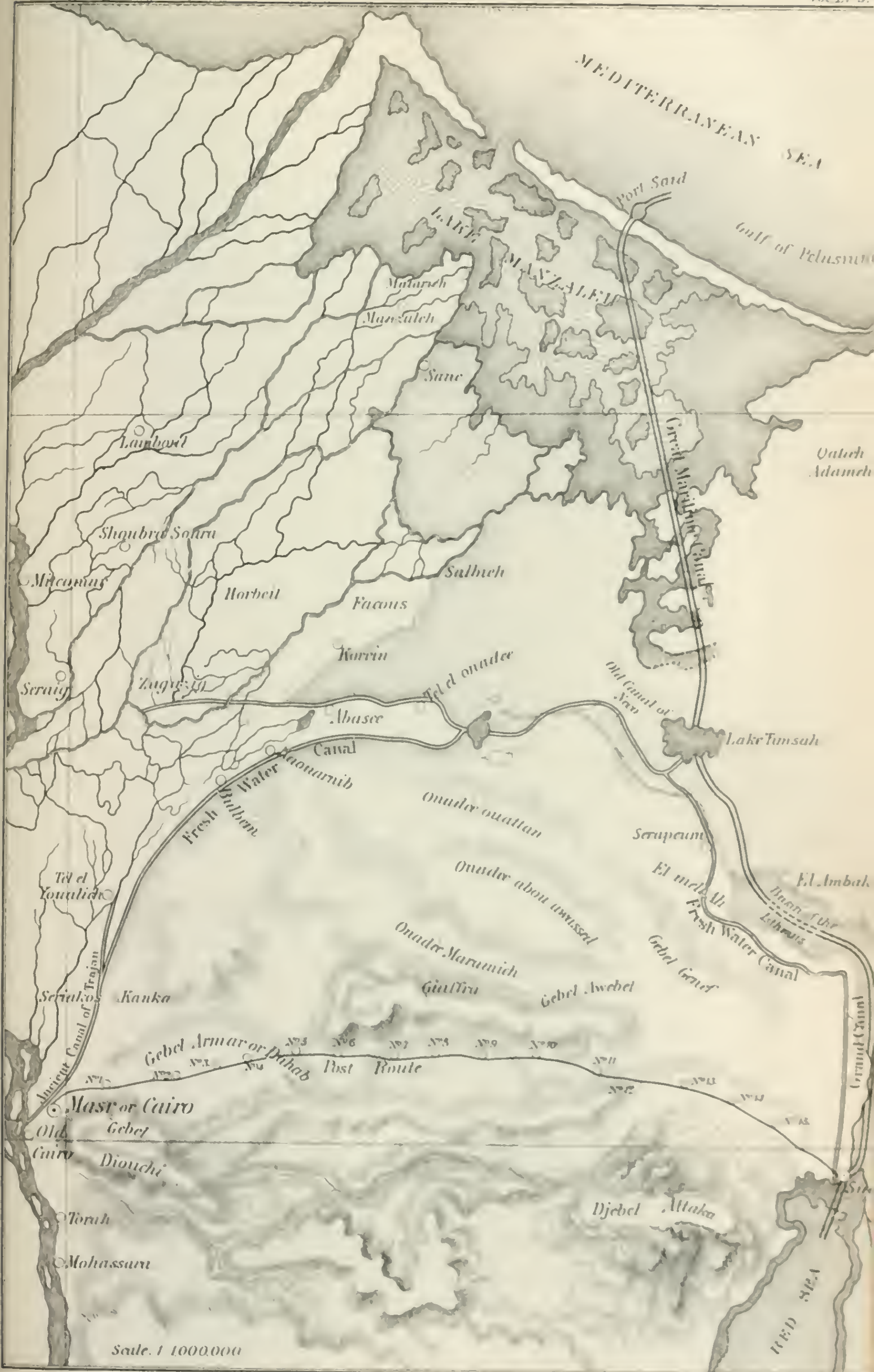
## THE SUEZ CANAL.

In view of the commercial importance of this enterprise, as well as the diplomatic prominence which it has attained of late years, it may be interesting to note the present condition of the work, the prospects of its early completion, and the probabilities of its being maintained as one of the great highways of commerce.

# The Suez Canal.



The facts here presented, were gathered while on an excursion along the line of the proposed canal, in March, 1867.

The present article will merely glance at the history of crossing the Isthmus of Suez by water, dwelling at length upon the actual work now undertaken, and the means employed in its execution.

The traditions of the Arabs, as well as the researches of Champollion and other Egyptian scholars, attribute the cutting of the first canal, which led from the Nile to the Red sea, to Sesostris or Rameses II., who reigned about 1300 B. C.

Pliny and Aristotle also mention Sesostris as the originator of this work. It is quite certain that Neco and Psammeticus, about 600 B. C., re-opened the ancient canal, which had been allowed to become filled with sand in some places.

Ptolemy Philadelphus still further improved the navigation, and added sluices to control the flow of water. which were at the same time made of sufficient capacity to allow vessels to navigate them.

After the conquest of Egypt by Cambyses, Darius came from Persia to take possession of the conquered province, and while there, caused the canal to be re-constructed. Herodotus, writing an hundred years later, gives an account in detail, of his passage through the canal, and mentions the fact that Darius had repaired it.

After the battle of Actium, Cleopatra endeavored to withdraw the Egyptian fleet through the canal to a place of safety in the Red Sea, but was prevented from so doing by the low stage of water in the Nile, at that season.

This circumstance drew the attention of the Roman Emperors, Trajan and Adrian, to the canal, and they caused another branch or feeder to be dug to the main body of the Nile, near to where Cairo now stands. This branch joined the ancient canal at Zagazig, and was continued thence to Suez.

The whole work was again neglected for many years, and was next repaired by order of the Caliph Omar, about A. D., 640. In 780, or thereabout, the Caliph El Munsoor Aboo Grafer caused the canal to be filled up, in order to prevent the export of breadstuffs to the province of Medunch, which was then in revolt.

The Sultan, Hakem, A. D., 1000, is said to have again put the line in navigable order; but certainly for a short time: as the southern or Suez end has long been choked with sand.

The northern or western portion of this ancient canal, from Zagazig to Gassassine, say 22 miles, has always been kept in order, for the purpose of furnishing water to irrigate a tract of land called "the Ouady," of about 30,000 acres, part of the Scripture "Land of Goshen," and where are now some 20,000 mulberry trees, and excellent cultivation.

The question of direct water communication from the Mediterranean to the Red Sea, has engaged the attention of several of the sultans of Turkey, but they did nothing to promote it.

While in Egypt, in 1798, Napoleon ordered his engineer, Mons. Lepér, to run a line of surveys across the Isthmus, to ascertain if the two seas were on the same level. The order was obeyed, but the work was done hurriedly, with poor instruments, and through the midst of hostile tribes; so that when it was announced that there was a difference of level of nearly thirty-three feet, no one placed any confidence in the report. The mathematicians, Laplace and Fourier, declared that this result was inconsistent with theory, and that there could not be any such great difference, if indeed there was any at all. Subsequent examinations have proved the correctness of their assertions; Mons. Bourdaloue, the eminent French engineer, having ascertained in 1847 that the difference of mean tide in the two seas was only about 6½ inches; the tides in the Mediterranean being from 9 to 12 inches; and in the Red Sea, from 50 to 70 inches.

In the autumn of 1854, Mons. Ferdinand de Lesseps visited Egypt by invitation of Mohammed Said, son of Mehamet Ali, then Viceroy, with the design of discussing the feasibility of constructing a ship canal of large dimensions, running directly from sea to sea. M. de Lesseps had been the French Consul General in Egypt, for the seven years succeeding 1831, and had already given much attention and study to this question, as is well known to the viceroy. The result of this visit was a preliminary concession or grant, in November, 1854, from Mohammed Said, representing the Egyptian government, authorizing M. de Lesseps to form a company for the purpose of digging the canal, and securing to such company the exclusive right of transit for 99 years, from the day when the work was finished.

A new and thorough survey of the isthmus, from Suez to the Bay of Pelusium, was commenced at once, by the engineers of the viceroy, Messrs Linant-Bey and Mougel-Bey, who completed their work in March, 1855. In February of this year, M. de Lesseps went to Constantinople, to obtain the sultan's confirmation of the concession given to him by the viceroy. The sultan and his grand vizier were most favorably disposed toward the enterprise, but were persuaded to withhold their formal assent thereto, through the influence and representations of Lord Stratford de Redcliff, the English ambassador. This was during the Crimean war, and the Turkish government were afraid of doing anything which might offend so powerful an ally as England.

The detailed plans of the isthmus survey by Linant-Bey and Mougel-Bey were finished in August, 1855, and in the following October were submitted for examination to an international commission of engineers, nominated by the governments of Austria, England, France, Holland, Piedmont, Prussia, and Spain. The commission first met in Paris, and in November five of the members went to Egypt to examine the whole question of the canal in detail, upon the ground. They returned to Europe late in January, 1856, and made their report in December of that year, confirming the feasibility and safety of the enterprise. Notwithstanding the fact that the sultan had declined to confirm the concession of the viceroy, M. de Lesseps succeeded in organizing the canal company, with a capital of two hundred million francs, and obtained a second concession in January, 1856, similar to the first, but much more in detail. The constitution and regulations of the company which was organized under the French law, were also submitted to the viceroy, and approved by him.

This matter of the Suez canal caused a good deal of discussion in the English Parliament, during the summer of 1857, and the spring following. Lord Palmerston opposed it most violently, as being contrary to the policy of the government on the "Eastern question;" at the same time, the commercial community favored the enterprise, on the ground of its facilitating their intercourse with India.

There appeared in the *Edinburgh Review*, for January, 1856, an elaborate article, going to show that the Suez canal could not be constructed; that it could not be maintained, even if it should be built, and that it would be of no benefit to any one, even if constructed and maintained, as a navigable channel for shipping. The *Quarterly Review* followed in the same strain. It was under these discouragements that M. de Lesseps commenced actual work, in 1859, although it was as late as March, 1866, before the final formal consent of the sultan was obtained, which put the matter beyond the reach of all further diplomatic interference.

The line of the ship canal, as determined by the commission of engineers, runs nearly north and south, from Port Said, on the Mediterranean, to Suez, at the head of the Red Sea, a distance of one hundred miles. The width at the water line will be 330 feet, with a uniform depth of 26 feet. The alignment is very favorable, there being but eight curves; the shortest radius is 6666 feet, with an angle of 143°. For nearly three-quarters of the distance, the canal will be dredged through a line of shallow lakes or basins, some of them containing brackish water, filtered in from the sea, and others being dry at present, indicating the locality where lakes existed at some former period. The intervening strips of land, are parts of the great Desert, which extends over so large a portion of Egypt, Syria and Arabia; an arid, desolate, waste, with nothing to sustain either animal or vegetable life. It was, therefore, a matter of the first importance, to introduce a supply of fresh water along the line of the proposed ship canal, to sustain the men employed, as well as to supply the boilers of the necessary steam engines. To accomplish this, the company dug an extension from the terminus of the ancient canal, at Gassassine, to a point on the line of the ship canal, midway between Port Said and Suez. This work was executed under the direction of Mons. Cazean, at an outlay of 700,000 francs; about thirteen hundred thousand cubic yards of earth being moved. The length of this fresh-water canal is 30 miles, the width at the water line 66 feet, depth 6 feet, with a fall of about 2 inches per mile. Its direction is nearly east, coming in at right angles to the line of the main canal at a point now called Ismailia, so named in honor of Ismail Pasha. From here, the water was, at first, distributed to the camps along the line of the ship canal, by transportation on the backs of two thousand camels and half as many donkeys, which were employed for that purpose, for many months. Afterwards a cast iron pipe, 6¼ inches in diameter, was laid from Ismailia to Port Said, a distance of 50 miles, and through this about 22,000 cubic feet of water have since been forced daily. There is now a second pipe laid, parallel with the first, of 10 inches diameter, furnishing about 32,000 cubic feet of water per day, additional. The pumping engine at Ismailia, is a beautiful piece of mechanism, made by Le Banneur & Pétan, Paris, rated at 50 horse-power. It was one time necessary that it should be kept running, night and day, for five consecutive months; and during this period, it was not once stopped. These water pipes are tapped along the line, at such points as required, to supply the men and engines there at work. The cost of these water-works has been about six million francs. The level of the fresh-water, at Ismailia, is 19 feet above that of the salt water in the canal, and two locks have been constructed, so as to form a navigable connection between them, and of sufficient size to allow the passage of boats 100 feet long and 26 feet wide. At a point on the fresh-water canal, 2½ miles above Ismailia, a branch canal takes off to the southward, extending for 58 miles, to Suez; this line was also constructed under the direction of Mons. Cazean, and cost about three and a half million francs; it was finished in 1863. By this branch fresh water is furnished to the camps and engines south of Ismailia, and also to the town of Suez; whereas, formerly, all drinkable water had been brought from the Nile, at Cairo, a distance of 90 miles, over the railroad. In still earlier days, the dependence was upon the "Wells of Moses," situated on the eastern side of the harbor, and this water, the best to be had, was decidedly brackish. It is by means of this last mentioned branch canal, that water communication has been opened between the two seas, and not through the length of the ship canal proper, as the public have been led to believe. The *northern* end of the ship canal, from Port Said to Ismailia, is, however, now sufficiently advanced to allow the passage of boats drawing five feet of water; and the current from the Mediterranean has been flowing through this portion for a number of months, and is daily filling up the basin of an ancient lake, "Timsah," at the point of junction of the fresh-water canal, from Gassassine to Ismailia, and the ship canal. History and tradition both inform us, that there once existed, at this point, a lake famous for the number of crocodiles to be found in it.* It must have been a fresh-water lake, and been fed by the overflow of the Nile.

The whole extent of the isthmus is covered with marine shells, similar to those which are now found in the neighboring seas, indicating, beyond a doubt, that at no very remote period, geologically speaking, the salt water stood at a higher level than it does to-day; and that the isthmus, as such, did not then exist. There is quite a remarkable depression in this neck of land, as now seen, and through this depression or valley the canal will be constructed. Port Said, at the Mediterranean entrance, is in latitude 31° 16′

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*The name "Timsah" in old Arabic, means *Crocodile*.

north, longitude 32° 19′ east. This point was selected for the reason, that just here the line of deep water is nearer to the beach than anywhere else along the coast. In the bay of Pelusium, it was found that the line of 33 feet soundings was nearly 4 miles from the shore, while at Port Said, the distance is only about half as great. The beach in all this region, is merely a narrow strip of sand one hundred or two hundred yards in width, inside this are a number of shallow lakes, or mere salt marshes, some of them of great extent.

(To be continued.)

## ANCHOR ICE.

In this *Journal*, Vol. 51, p. 327, was published an account of the formation of ice on a strainer connected with the inlet pipe of the Detroit Water Works, and at a depth of 25 feet, together with the opinion of Professor S. H. Douglass of the University of Michigan. In the following volume 52, p. 101, appeared, with editorial endorsement, the reply of Professor Douglass to objections which had been urged by Professor Henry, against his explanation. On page 236, of the same volume, we find an excellent paper, by J. B. Francis, C. E, confirming the views of Professor Henry. Having thus referred to the history of the subject, as far as this *Journal* is concerned, we will briefly record the results of sundry experiments, which have been made at the Detroit Water Works, upon the strainer in question, and fully establish the true theory and explanation of the action. This record we take from the Report of the Board of Water Commissioners of the above place. After a description of the strainer, which is of so simple a description that it need not be here repeated, we find as follows:

"Under certain circumstances, during extreme cold weather, it is with difficulty a supply of water can be obtained, in consequence of the accumulation of ice on the strainer, frequently requiring the speed of the engine to be reduced, and at times to stop it for several hours together, no water passing through the pipe into the well, notwithstanding the bottom of the well is twelve feet below the surface of the river. The size of the well is about forty feet long, eighteen feet wide, and twelve feet deep. The circumstances under which the difficulty occurs are, when the weather is cold, and ice is forming in the lake above, and on the shores of the river, and the river is free from ice over the strainer. But when the river is covered with ice over the strainer, the difficulty does not occur at any degree of cold.

This fact induced us to suspend a line of booms from the wharf some distance above and outside the strainer, so as to retain a covering of ice over it when the rest of the river was not covered. This boom was successfully kept in position until the ice firmly formed inside of it, but failed to accomplish the object. The theory that the covering of the entire surface of the river by ice prevented radiation, and by that means the ice did not form on the strainer, was strongly urged; and, if so, any covering over the strainer would answer the same purpose. To test it, we, last summer, employed the submarine divers, Messrs. Harrington and Philips, to build a submerged platform of planks immediately over the strainer, which they successfully accomplished, but which, however, proved of no avail, for the stoppages occurred at a higher temperature than before.

On the 29th of December last, while but a small supply of water could be produced, we induced Mr. Harrington to go down to the strainer and make an examination of its condition. Owing to the extreme coldness of the water and atmosphere (the thermometer on the wharf marking twenty-six degrees), it was impossible for him to remain down beyond a short time, but this was long enough to discover the fact that the strainer, with its surrounding spiles, was one mass of ice, particles collected into a mound some ten feet high, and about fifteen feet in diameter, and that large quantities of minute crystals of ice were rapidly passing and adding to the mass already collected. Specimens of the ice were brought to the surface in a bag. It was in sheets and particles thin as paper, translucent, with sharp, pointed edges. A further examination developed the fact that the small amount of water the pump was then receiving came through the lower or down-stream side of the strainer, this being the only point where he could approach it, and which was found but slightly covered with ice. When these facts were ascertained, we thought we were about to solve the problem and provide a remedy for the difficulty, especially as a similar experiment to the one we then proposed to adopt had been successful at the Buffalo Water Works. It was to inclose the strainer, except a part of the down-stream side, so as to prevent these floating particles from collecting on and around it. To do this, a large piece of canvas was prepared of suitable size, and firmly fastened by the diver around the spiles, which, with the platform, completely covered and encircled the strainer, except on the down-stream side. This was but just completed when the weather became colder, and during the night the thermometer indicated several degrees below the freezing point, and before daylight the engine stopped for want of water. Preparations were made as speedily as possible, for another descent to the strainer. At 11½ o'clock, A. M., the diver went down, and this very important fact was ascertained, that, with the temperature of the atmosphere at twenty-nine degrees, the water at the surface was thirty-three degrees, whilst at the bottom of the river it was thirty-five degrees. At this descent much less ice was found on the strainer and its surroundings, than the first time. The lower side was clear, but on the upper side the action of the current had worn the ice into elongated cones, pointing up stream. At this time the pump was receiving a full supply of water. About three hours later, the diver again descended (thermometer thirty-three degrees); he found the ice had entirely disappeared. The wooden platform was removed, since which time no trouble was experienced up to the evening of the 24th inst., when the surface ice of the river was in motion. From 1 o'clock, A. M., of the 25th inst. (thermometer sixteen degrees), no water could be obtained until daylight, when the engine was again started, and no further delays have since occurred.

Your committee, by the aid of the submarine diver, have ascertained the fact that at certain temperatures these ice particles are ever present in the river, and are continually passing down by the action of the current, and whatever obstructions they meet with in their passage they collect upon. This being the case, we recommend, the coming summer, the entire removal of all spiles and other substances adjacent to the strainer, believing that with nothing but the smooth dome of the strainer for these particles to lodge upon, the quantity that will accumulate cannot very seriously prevent the flow of water to the inlet pipe."

The report from which the above extracts are made, is signed

S. G. Wight,
J. Owen,
*Committee on Supply of Water.*

## THE LOUISVILLE BRIDGE.

As long ago as 1829, a charter was granted by the legislature of Kentucky, for the construction of a bridge over the Ohio River at Louisville. Operations were commenced, but were shortly after abandoned for want of capital.

In 1856 a new charter was granted, and under this charter the Louisville Bridge Company was organized.

The first stone was laid by Messrs. Nash, Flannery & Co., the contractors for masonry, on the first day of August, 1867, and since that time the work has progressed favorably. Owing to the extraordinary season of low water during the past summer and fall, the piers were put in at a much less expense than was anticipated.

The contract agreed that the work should be completed by the first of September, 1869. The company, however, having offered a liberal bonus for the completion of the work before the time specified, we see no reason why it should not be accomplished. The estimated cost of the bridge is $1,500,000, which does not include the right of way and depot grounds, which latter may be estimated at $100,000; total cost, $1,600,000. The expenditure thus far amounts to $160,203.85.

Two plans of construction were submitted to the Board of Directors; one contemplating the construction of the bridge merely for railroad purposes, the other for the use of vehicles of all descriptions, including street cars; the latter plan was the one adopted. The following are the general features of this plan:

The grade of the road approaching the bridge on the Kentucky side, corresponds with the grade at the point of crossing High Street, from which place it ascends at the rate of eighty-two feet per mile, striking the first span of the bridge at an elevation of sixty-one feet above low water, and continuing at the same rate until it reaches an elevation of ninety-five feet above low water in the middle chute.

From this point the grade of the bridge is level for a distance of 2,213 feet, at a level of 101½ feet above low water. The grade then descends at the rate of 78 8/10 feet per mile, reaching the northern abutment at an elevation of thirty-five feet over the surface of the ground.

The grade of the approaches continues to descend until it strikes the surface of the ground. The superstructure will be placed below the grade of the road, except where it crosses the middle and Indiana chute. The lowest point of the superstructure over the middle chute, is 102½ feet above low water, and over the Indiana chute, 96½ feet; the low water in the Indiana chute being six and a half feet lower than in the middle chute. A draw-bridge of 114½ feet clear span on each side of the pivot pier, will be built over the canal. The entire length of the superstructure is 5,280 feet; the longest span is that over the middle chute, which is 370 feet. A peculiar feature consists in the fact that the railroad track is to be laid in the centre, the two street tracks on either side; one rail of the railroad track, in addition to another rail on either side, will form the two street railroad tracks.

No street cars or other vehicles can cross at the same time as a locomotive, but street cars and common carriages can pass each other at any place on the bridge.

The time occupied in crossing over the bridge by a locomotive and train, will be about five minutes. At present the Jeffersonville Railroad runs daily, six trains each way over their road, and will, therefore, occupy the bridge for one hour in twenty-four. Of these, seven trains will cross over the bridge during the hours of 6 A. M. and 8 P. M., leaving, therefore, the use of the bridge for thirteen hours and twenty-five minutes unobstructed to the crossing of street cars and wagons.

The superstructure of this bridge will consist of Fink's patent suspension trusses, except the channel spans, which are to be of the triangular plan, arranged by the same gentleman.

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## WOODEN PAVEMENTS.

Reply and Report of Chas. H. Haswell, to a communication from a number of Tax-payers of the City of New York.

New York, *February* 21*st*, 1868.

Gentlemen,—Your letter of the 13th inst., regarding Wooden Street Pavements, is received and considered, and in reply thereto, I submit as follows:

The only wooden pavements now before the public for competition, that I have investigated, are those of Mr. Nicholson and Mr. C. Williams.

That of Mr. Nicholson is constructed of white pine blocks three inches in width, six inches in depth, and of lengths varying from six to twelve inches, set transversely to the line of travel upon them, with an intervening space or fissure between their transverse courses, which is defined by a strip of wood laid at the base of the blocks; the whole resting upon a layer of white pine boards over an ordinary sand-bed; and for the purpose of attaining durability of the wood, as alleged, its surface is coated but very imperfectly, with coal-tar.

That of Mr. Williams is constructed of yellow pine blocks twelve inches square by six inches in depth, set directly in connection with each other, and resting upon a concrete of rubble and asphaltum, with grooves at proper intervals upon the face of the blocks, running transversely to the line of travel. The direct connection of one block with another, affords support to resist the lateral stress of travel, and the concrete gives support to the blocks in their resistance to a vertical stress.

To meet the requirements of endurance to wear and resistance to decay, it is purposed to fill the pores of the wood with an oleaginous fluid, of such consistency as will retain its condition, and thereby not only preserve the wood from decay, but give such support to its fibres as will essentially add resistance to the crushing stress of loaded vehicles. This fluid is condensed from a vapor at high temperature, whereby the watery particles of the wood are dispelled, and the albumen solidified.

Wood in its ordinary conditions, when used for pavements, is subjected to decay and the destruction of its fibres, by the crushing effects of loaded vehicles and horses.

In the former case, if the wood is seasoned, it is subject to *common rot*, from its alternate exposure to moisture and dryness, and if it is unseasoned, it is subject to *dry rot*, by the putrefaction of its vegetable albumen and fermentable elements, as well as to the effect consequent upon its alternate exposure to moisture and dryness.

Wood is altogether too porous in its structure, for endurance to the wear of loaded vehicles, and by the crushing of its fibres it is rendered liable to decay; for if it is seasoned, the abrasion of its surface and the imperfection of the coating, given it by Mr. Nicholson, exposes it to alterations of moisture and dryness, and if it is unseasoned, the coating of its surface with coal-tar or any like substance, by retaining the fluids, hasten its decay. There is a common but fallacious idea, that the charring of unseasoned timber, as is practised in setting fence posts, preserves it: on the contrary, the painting, coating or charring of unseasoned timber hastens its decay.

Reviewing, then, the elements presented, I am of the opinion—

1st. That wood in its ordinary condition, is unsuited as a material of pavement.

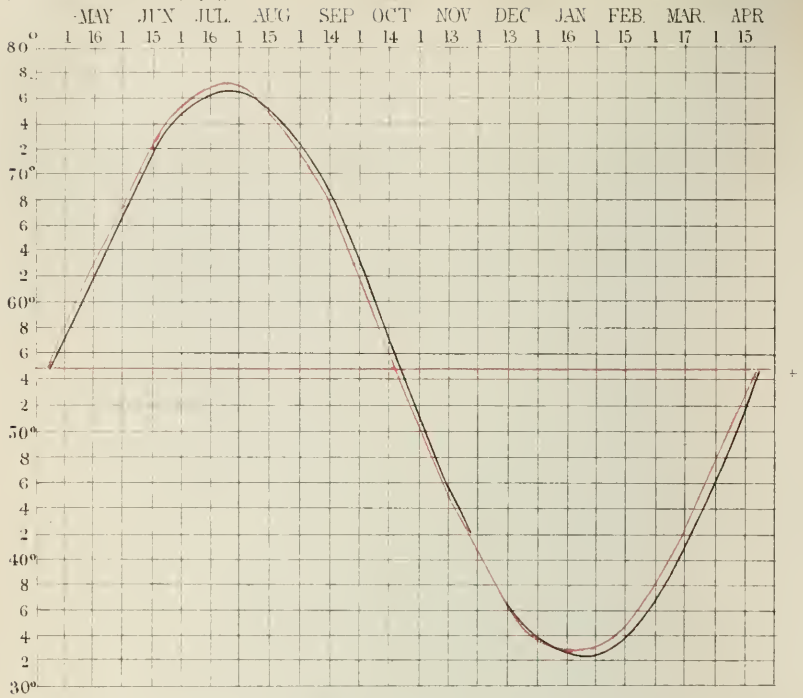
2d. That the wooden pavement now being laid in this city, will not meet the public demands in relation to its economy of maintenance and endurance to wear.

3d. That white pine or any other wood of like porous structure, is altogether unsuited for the requirements of a wooden pavement, unless its contained albumen has been solidified, its fluids expelled, and its pores filled with an antiseptic or oleaginous liquid of such consistency as will retain its condition.

4th. The immediate connection and consequent lateral support of one block with another, in the plan submitted by Mr. Williams, added to the great extent of the bottom surface, resting upon a bed of concrete, will ensure all the stability that it is practicable to give such a structure, within a practicable cost, and that the treatment for preservation as proposed by him, will ensure that endurance of the wood which the requirements of the case render imperative, in cost of maintenance, resistance to wear, and the sanitary condition of the city.

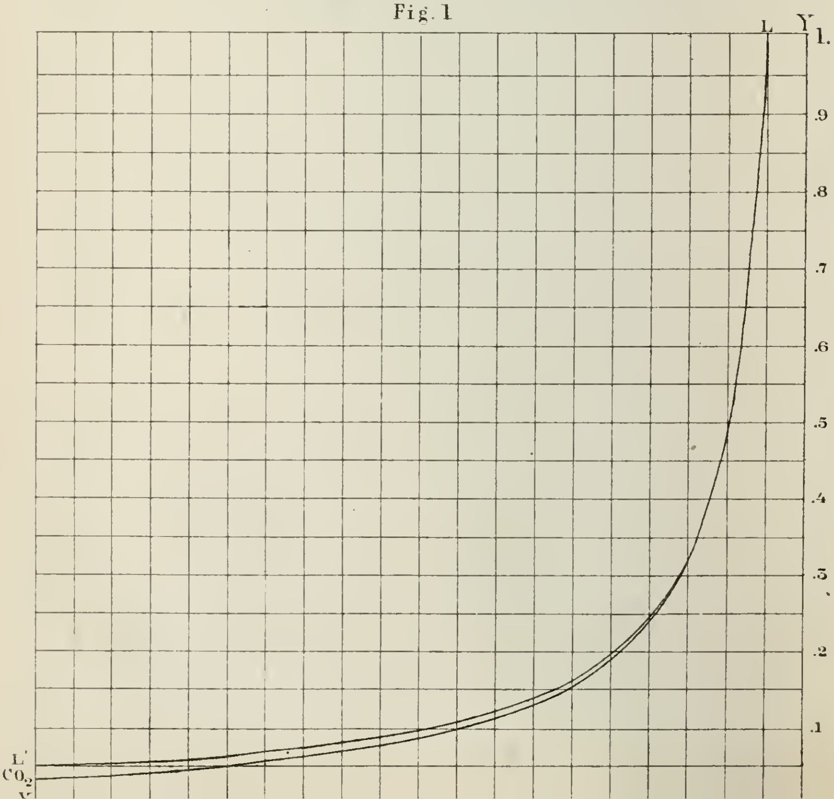
Finally, so imperative are the requirements of durability even in woods exposed in a less manner than in street pavements; that talents and attainments of the highest order have been taxed to meet them, as developed in the essays of Ryan, Burnett, Boucheri, Bethel and Robbins.

I am, respectfully,
Yours, &c.,
CHAS. H. HASWELL.



THERMAL CURVE OF BALTIMORE WITH CORRESPONDING SINUSOID.

Fig. 1



# Mechanics, Physics and Chemistry.

## LECTURE-NOTES ON PHYSICS.

By Prof. Alfred M. Mayer, Ph.D.

(Continued from page 196.)

### § IV. *Manners of Expressing a Law—Law evolved from the numerical results of Observations and Experiments.*

The first step in that investigation, which has for its object the discovery of the law of a class of facts, is the minute examination and description of the phenomena and of the circumstances which accompany them, and the determination of those conditions necessary for their production. This having been accomplished, we observe that there always exists between the different circumstances of an associated class of facts, relations or dependencies which bind them together in such a manner, that if we change one of the circumstances of the phenomenon, the others experience determinate modifications.

For example. In the compression of air, we have seen that the smaller the volume into which the air is forced, the greater the force of compression required; and on further examination with *measurements* taken of (1) the volumes occupied (2) under different pressures, we find that the relation which binds (1) and (2) is that *the volumes of the air are inversely as the pressures to which it is subjected.*

Such an expression of the relation existing between the different circumstances of a class of associated facts is, as we have seen, (§ I.) *a physical law.*

"These laws rule all phenomena, and are their most complete representation. Their existence did not escape the acute minds of the philosophers of antiquity. Plato, questioned concerning the occupations of the Deity, replied that *He geometrized without ceasing;* wishing thereby to express according to Montucla, that the universe is governed by geometrical laws" (Daguin's Traite de Physique, Vol. I., p. 8).

If the law is the expression of a general *quantitative relation* existing between the associated facts of the phenomenon, it can be replaced by a line referred to coördinate axes, as in the method of Analytical Geometry.

*Example* 1. Thus, *a Parabola* represents the law of falling bodies, because the origin of rectangular coördinates being at the principal vertex, the abscissas are to each other as the squares of their corresponding ordinates; or,

$$x' : x'' :: y'^2 : y''^2;$$

and the law of falling bodies is that *the spaces fallen through are as the squares of the times;* therefore, if any ordinate represent in units of length the units (seconds) of time occupied in the fall, the units of length contained in its corresponding abscissa will give the units of length fallen through; one unit of length in this case—being a function of the intensity of gravity—is, for the latitude of New York, equal to 16 feet 1 inch.

The above is directly shown in MORIN'S MACHINE, where the body describes the parabola by falling parallel to the axis of a uniformly revolving cylinder, against which a pencil, attached to the falling body, gently presses. The curve thus formed is found on spreading out the paper, which covers the cylinder, and measuring its abscissas and ordinates, to be a parabola. Thus, in this beautiful experiment, the body itself writes on the paper the law of its motion.

*Example* 2. The law of the compression of gases is given by a curved line (see Fig. 1, Plate III. Curve L L′), whose abscissas representing pressures and ordinates volumes, has for its equation

$$y = \frac{1}{x}$$

This curve is an equilateral hyperbola, and therefore the axes of $X$ and of $Y$ are asymptotes to the curve; and this should be so, for the gas, supposed to be non-liquifiable, has under an infinitely great pressure, still a definite volume, which is expressed by the ordinates corresponding to that pressure. If, however, the gas is not permanent (like carbonic acid), the curve will cut the axis of $X$ at a point corresponding to the pressure producing liquifaction. If all those gases which are susceptible of liquifaction—though the pressures required for this result for certain gases might be beyond the limit of practicable experiments—had curves whose deflections towards the axis of $X$ all followed the same law, we could, by projecting the curve of any gas, as far as the limit of experiment, determine at what point it would cut the axis of $X$, and thus determine the pressure of liquifaction.

See Fig. 1, Plate III. The curve L L′ represents Mariotte's law, that the volumes of gases are the reciprocals of the pressures; while L $CO_2$ shows the fraction of a unit of volume, measured on the axis O Y, occupied by carbonic acid gas under pressures, from 1 up to 20 atmospheres, measured on the axis O X. If the curve of hydrogen were projected on this diagram, it would sweep above L L′, departing very slightly from this line on the side opposite the curve, L $CO_2$.

The advantage of the graphic method of expressing a law is, that it represents *to the eye* the *continuous* relation between the associated facts of the phenomenon, and therefore gives, by direct measurement, the quantity answering to any measure taken of either of the related magnitudes embraced in the projected curve. Also, by the mathematical discussion of the curve, new relations which otherwise might pass unknown, may be evolved.

Sometimes the relation existing between the associated facts is too complicated to be susceptible of a concise quantitative statement. In that case, we lay off on an axis of rectangular coördinates lengths of abscissas equal to various values of one of the quantities, and on their corresponding ordinates lengths equal to the corresponding values of the other quantity. We then draw *libera manû*, through the several points thus determined, a curved line, and this line will be the *continuous expression* of the relation existing between the two quantities considered.

It may happen that the inspection of the curve leads to the discovery of a law, which we could not have made from the direct comparison of the numbers given by experiment or observation. For example, if the curve was one of those lines studied by geometers, and whose properties are well known, the relation which exists between the abscissas and ordinates of the curve, or, in other words, its equation (referred to the axes $X$ and $Y$), will express the law which we seek. If, therefore, we recognize by mere inspection, that the curve resembles a known line, we must proceed in the following manner to the verification of that supposition. We write the general equation of the curve, referred to the axes $X$ and $Y$, giving it indeterminate co-efficients; we then successively substitute in that equation as many values of $x$ and of their corresponding ordinates $y$, as there are co-efficients; which gives *equations of condition*, by means of which we calculate the values of these co-efficients, which we then substitute in the general equation. We then successively substitute for $x$ and $y$ other numerical values given by the experiments or observations, and we examine if these numbers satisfy the equation. If this is the case, we conclude that the curve is really the one we suspected, and its equation expresses the mathematical law of the phenomena.

For a simple example, take the curve described by Morin's Machine for showing the law of falling bodies. If, from preliminary measurements, we suspect the curve to be a parabola, we have, for the general equation of that curve—

$$y^2 = 2\,p\,x;$$

in which, placing $x'$ and $y'$ from measured coördinates of the curve, we have—

$$2\,p = \frac{y'^2}{x'}$$

substituting this value of the parameter in the general equation, and making $x$ and $y$ successively $x''$ $y''$, and $x'''$, $y'''$, &c., obtained from other measurements on the curve, we find that—

$$y''^2 = 2\,p\,x''; \; y'''^2 = 2\,p\,x''', \&c.$$

whence we conclude that the curve is the quadratic parabola, and therefore—

$$x' : x'' :: y'^2 : y''^2;$$

and since in the curve described by this machine, $x'$ and $x''$ are equal to the spaces fallen through by the body in the corresponding times $y'$ and $y''$, we have the law that *the spaces fallen through are as the squares of the times.*

Example, in which more complex relations exist—

We have (in a paper preparing for publication), projected the thermal curves, of the variation of temperature from day to day throughout the year, of fifteen places, differing in latitude, longitude, elevation above and distance from the sea, and in other topographical features; and on discussing these curves, we find that they can all be replaced by *sinusoids*, differing from each other only in the amplitude of their flexures, which corresponds to half the annual range of temperature of the different stations.

Lengths of abscissas standing for days and lengths of ordinates representing degrees of temperature (see Plate III., Thermal Curve of Baltimore, with corresponding sinusoid; where the horizontal red line marks the mean annual temperature, while the curved red line is the annual thermal variation, and the curved black line its corresponding sinusoid), we obtain a series of points, by laying off on ordinates erected from abscissas corresponding to certain days, the mean temperatures of those days, and then drawing a curved line through these points, we have the annual thermal curve. This curve has its origin at the point of the axis of $X$ which corresponds, in the average, to the date of the 21st of April; the mean temperature of that day being the mean temperature of the year.

(Diagrams of thermal curves, with corresponding sinusoids of fifteen stations exhibited.)

Now projecting on the line of mean annual temperature of each curve, as the base, *a sinusoid* the length of whose base ($=360°$) equals the length of the year; whose point of origin is on the base at the point corresponding to the 21st of April, and whose amplitude equals the half yearly range of temperature, we have, in every instance, so close a coincidence between the thermal curve and the sinusoid, that we can confidently say, that the variation of temperature throughout the year follows the variation of the sinusoid curve.

The equation of the sinusoid is—

$$y = sin.\ x;$$

and as the sines of the first and second quadrants are + and of the third and fourth —, it follows that this is a recurring curve, and up to $sin.\ (x = 180°)$ the flexure is above the base line, while from $sin.\ (x = 180°)$ up to $sin.\ (x = 360°)$ the curve lies below the line, and so on; each succeeding 180° being on the opposite side of the line of mean temperature from the preceding.

Therefore, expressing any date in days reckoned from April 21st, and converting these days into lengths of arc $= x$ at the rate of one day $= \frac{360°}{365} = 0°\ 59'\ 1''$, and making the sin. 90° or $R = \frac{1}{2}$ the mean yearly range of temperature, we can readily determine the mean temperature of any date of the year.

1. *Problem.* What is the mean temperature of the 10th of June, at Paris?

The mean annual temp. from 46 years observations, =51·° 3 Fah.
Half the yearly range, . . . . . . =15·° 47
Days from 21st April to 10th June, . . . =50 days.
The above number of days in arc, . . . =49° 10′ 50″
Natural sine of above arc, . . . . . . =·756773
Radius in this example, . . . . . . =15 47
Then the temperature of 15th June equals
·756773× 15°·47 +51°·3 . . . . =62°·90
Mean temperature of 15th June, from observations of 46 years, . . . . . . . =62°·99
Difference, . . = 0°·09

2. *Problem.* What is the mean temperature of the 13th of Dec. at Baltimore? The temperature from *observations* = 35°·6. Data for solution. From 35 years observations, the mean annual temperature = 54°·4. The yearly range = 44°·4.

3. *Problem.* Calculate the mean temperature at Baltimore, of of the 14th October. The observed mean temperature of this day is equal to 56°·5.

4. *Problem.* Determine which is the warmest and which is the coldest day in the year at St. Petersburg. Data for the solution. Mean temperature, 38°·75. Annual range, 50°.

From observations of 30 years, the warmest day at St. Petersburg is on the average, the 25th July; the coldest, the 19th January.

We can therefore determine the mean temperature of any day of the year for any station (not situate in the tropics), whose mean temperature and yearly range of temperature are known. The mean temperature of any place can be found by taking the temperature once a month during one year, of any spring which issues from a depth of a few feet below the surface of the ground. Thus, the temperature of a spring in Baltimore, from the mean of one observation a month, during one year, was 54°·25, only 0°·15 below the mean given by 35 years observations of the thermometer in the air.

If a law could be established connecting different parallels of latitude with the yearly range of temperature, we could arrive at the other datum, and then the curve of annual variation could be projected from a knowledge of the latitude and longitude, with the determination of the mean temperature of a spring.

This method of representing to the eye, by means of curved lines, the nature of the laws concealed within a mass of numbers, presents the advantage of representing the continuous and periodical nature of cosmical action. It also presents to the eye *a form*, easy to seize and remember, instead of an abstract statement referring to relations of quantities, difficult to be conceived and sometimes impossible otherwise to discover. Thus the thermal curve of Berlin is the graphic expression of the relation of the 365 days of the year to observations made three times a day for 110 years, or, to 120,450 separate numerical quantities.

The curves show by their deformities, either that our data are not the results of sufficiently extended observations to give, by their projection, the expression of a law, or, that another cause is acting which increases or diminishes the effect due to the cause whose rule of action is expressed, in the main, by the curve.

Thus, in the thermal curves of Greenwich, of Paris and of Rome, an upward deflection exists, from the middle of January to the middle of April, causing a departure of about 2° Fahr. from the sinusoidal curves. This departure, at first sight, would appear as opposed to the assumption that the annual variation of temperature follows the variation of the sinusoid; but, in reality, it is "an exception which proves the law;" for it is found that during those months the prevailing winds for those stations are W. S. W., and Dove has conclusively shown that in the northern hemisphere, the thermometer stands highest, on an average, with a S. W. wind. This deflection, however, does not occur in the curve of Berlin, and there a S. 17° W. wind prevals during those months. But this is easily accounted for, and the explanation will at the same time give a sufficient reason for the upward deflection of 2° in the thermal curves of Greenwich, Paris and Rome.

The prevailing wind of Greenwich from the middle of January to the middle of April, reaches that station after having traversed the Atlantic ocean, whose surface water has, during the above months, even in the latitude of the English Channel, an average temperature of 52° Fahr. Now, one cubic foot of water in cooling 1° Fahr. will give out heat sufficient to raise 3080 cubic feet of air 1° Fahr., and the wind after traversing this surface of a liquid, of high specific heat, 13°·5 above the mean temperature of the air during February, passes over only about 85 miles of lowlands before reaching Greenwich. The same prevailing wind reaches Paris after having also passed over the Atlantic,—of even a slightly higher temperature than in the case of the Greenwich wind,—and traversed about 250 miles of land-surface not likely to affect its temperature, since this very land has received its thermal condition mainly from the supernatant air; but the S. 17° W. wind reaches Berlin after having crossed the snow covered summits of the Appenines and Alps, and 750 miles of land.

This general graphic method of expressing the relation which pervades a class of facts, evidently gives a ready means for *interpolation*, and even where *deformities* exist, a mean or true curve can be obtained by *sweeping* a line through the mean position of the irregularly placed points given by the observations or experiments. By this last method, Sir John Herschel determined the orbits of several of the double stars (*Transactions of the Royal Astronomical Society*, Vol. V., 1832), and M. Regnault (*Mémoirs de l'Institut*, *t.* 21, 1847, page 316, *et seq.*, and page 574, *et seq.*), from his measures of the tension of vapor of water corresponding to different temperatures, succeeded in ascertaining the extreme oscillations of the errors of those measures, by drawing a mean curve through the sphere of the points given by his experiments. He then substituted this curve for the numbers directly determined by experiment, because this curve expressed the relations of those numbers practically corrected of their errors.

It should be remembered that each number at which we finally arrive, before we place it down as a point to serve in the projection of the curve, is *the most probable mean* which we can obtain from the discussion of the numbers from which it is derived, (see § III.), and that each of these points so determined is arrived at independendently of any other point, and therefore the graphic method is especially adapted to combine all of these independent determination of points in one curve, and to make them mutually correct each others errors.

The curve thus obtained can be rendered more serviceable in practice, by obtaining from it, if possible, an equation which will express it; but if we find that it cannot be expressed by a single equation, we can, by the aid of *formulæ* of *interpolation*, find the value of each ordinate corresponding to as small an increase in each successive abscissa as we desire. We should not, however, apply a formula of interpolation to the numbers before we have obtained from them a mean curve. The interpolation is merely used to give a ready means of obtaining the values of any related magnitudes expressed by a curve, which shows the relations of the numbers corrected of their errors; for, as M. Regnault remarks, "the graphic method when it is properly executed, is preferable to all methods of interpolation by calculation; it permits us to distinguish, immediately, the variations due to the accidental errors of the observations, and the constant errors which depend on the diversity of the methods which we have employed."

(To be continued.)

# THE AIR-TIGHT GALVANIC BATTERY.

By Chas. T. Chester, Esq.

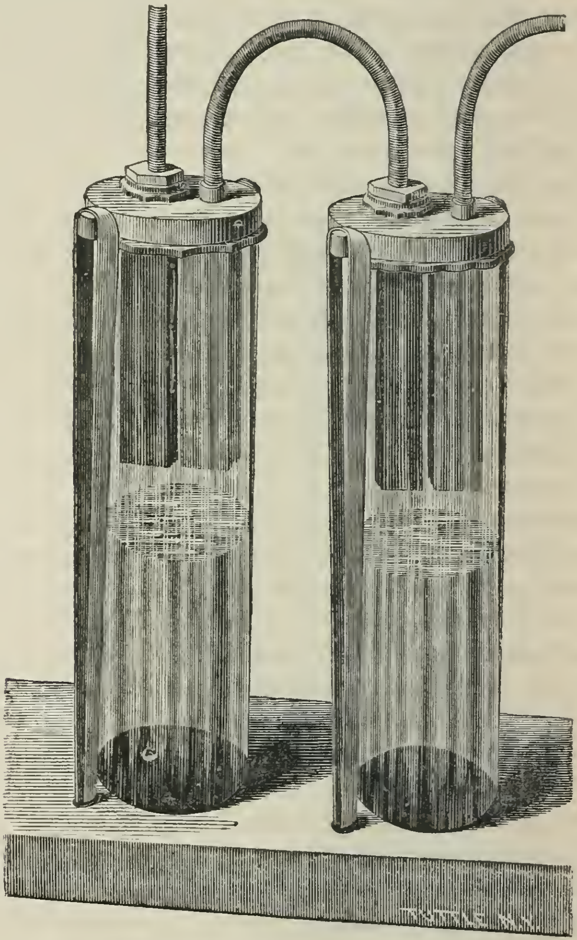
The galvanic battery serves many important purposes, which no other apparatus properly supplies. But the use of acids, with the destruction of material that they occasion, the space occupied, the expense and trouble attending their care, have prevented many from using any combination for producing dynamical currents of great intensity. Induction currents from coils of wire and magnets have formed a convenient substitute for those generated by the acid batteries, but it is becoming recognized that these induction currents will not produce the same effects as those from batteries, and especially for electro-therapeutics, an effort is being made to produce a battery of long endurance, and requiring little care. In Europe, wherever the teachings of Remak and his followers have prevailed over those of Duchenne, the great advocate of the Faradaic (or induction) currents, much attention has been given to the production of a good galvanic battery, easy in management, and not too self destructive. The ingenious manufacturers of France and Germany have made several useful batteries, but all of them of considerable size, and not portable. The principle aimed at has been, in almost all cases, to place certain plates and chemicals together, but also so to manage the diaphragm that chemical action is controlled. The stronger or denser the diaphragm, the slower is chemical and electrical action. Most of these combinations have been modifications of the sulphate of copper battery of Daniell. The battery of Stöhrer is made up of more energetic elements, viz: zinc, carbon, and chromic acid. These, when immersed in an acid, both form a very self-destructive combination. So it is arranged that the carbons shall be raised at pleasure out of the glasses, and to effect this easily, the usual porous cell is omitted, and a hole in the carbon cylinder receives the chromic acid. Practically, this beautiful arrangement gives much trouble, and in all of these batteries the waste of material is not due to the useful currents drawn out on medical practice, but to self-destruction in the elements. We think that we shall show that as far as medical electricity is concerned, we need not resort to batteries of great plate surface and "quantity" power, and there are other uses for which small batteries of great intensity may prove quite as powerful as those of much greater size, as for instance, the testing of long telegraph lines and delicate instruments in many electrical researches, and in the ignition of blasts in mining and excavations. For this last purpose, magneto-electrical machines have been provided, which give sufficient quantity and intensity to fire a large number of fuses at one time, by the ignition of an exceedingly attenuated conductor, like the mark of a lead-pencil. The force of these machines has to be nicely adjusted to secure precision in blasting, and a small battery of adjustable force would be an excellent substitute. For all these purposes, a battery requires to be used only a short time at once. We wish, therefore, to find some arrangement that will give currents of sufficient quantity, adjustable, however, to our requirements, also capable of a very high intensity, but also adjustable; it must be brought into action speedily. It must remain out of action indefinitely, without loss of power. It must be portable, clean, and not too expensive.

In the attempt to produce such an instrument, a number of questions must be solved. First: What amount of battery "quantity" is necessary for currents through the body, or similar resisting media, such as long telegraph circuits? Secondly: Can we find any combination of elements in a very small space that will give us this force? Third: Can we dispense with acid? Fourth: Can we absolutely remove the elements from the exciting fluid when the battery is not in use? Fifth: Can we prevent evaporation and the generation of gas? Sixth: Can these other requirements be made consistent with simplicity of structure and great ease in renewal?

In answer to the first, we have testimony extending through two or three years. In the Journal of *Psycological Medicine*, July, 1867, we have an account of a voltaic pile, consisting of perforated zinc and brass wire gauze, excited by cloth moistened in acetic acid.

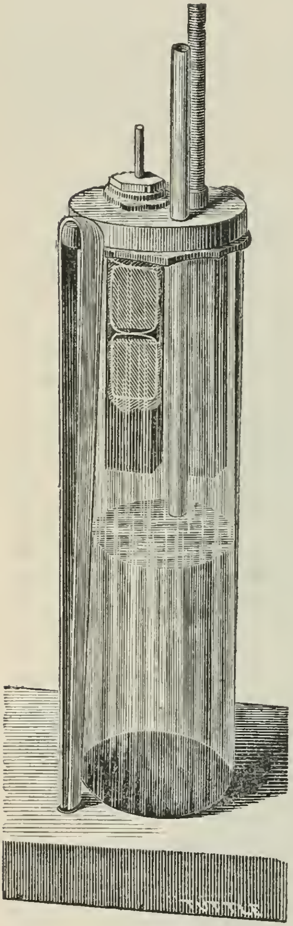
These plates were about two inches square, and numerous. During two or three years use, it had touched certain cases in which the induction currents commonly used, had no effect whatever, muscular contractions taking place instantly with the pile, but not with the inductive apparatus. In other hands, similar effects were produced. Paralysis yielded to these galvanic currents. The piles would produce, when their current was broken rapidly, shocks similar to those from inductive apparatus, but superadded and accompanying these evidences of currents of high tension, an appreciable "quantity" current was present. A sensation may be produced by a current of exceeding small quantity, as will be shown, but a degree of "quantity" higher than that produced by coils is necessary in many medical cases.

The piles, though efficient, are practically very troublesome and uncertain. A convenient substitute would be valuable, whose "quantity" current at least equals that of the pile. The battery we propose to describe, is capable of giving a range of effects from 256 down to 0. We will describe, without entering into detail, some experiments made in comparison with well known forms of battery, and we will term "electro-motive force" the power exerted to move certain magnetic instruments. In its highest activity, one cell of the new battery gave a force equal to that of a Smee battery, exposing 16 square inches of zinc surface; when nearly spent, the force equalled that of the same Smee battery, exposing 1/16 inch surface. The range is here from 1 to 256. To equal the force 1, fifteen plates of the pile, soldered together for surface, were required. The greatest power of the battery therefore exceeds that of one set of pile plates 3840 times. Now batteries of different kinds have been employed to drive currents through the body, having ten times the quantity of the 16-inch Smee, and thus a force 38,400 times greater than that of the pile has been attempted to be passed through a very resisting medium, and it would seem that curative or other effects must be enhanced, if the attempt be successful. How much "quantity" current can pass through the body or other resisting media, is a question of interest. We can easily ascertain the "resistance" to conduction of the human body, by moistening the hands, and grasping electrodes. We find that the "resistance" equals almost 550 miles of telegraph iron wire. It is well known that we cannot cause "quantity" currents to pass through this length of conductor. It requires much intensity to produce magnetic and other effects, and quite delicate instruments to indicate it. We may use a battery, which, with short conductors, acting directly upon a magnet, would raise 500 pounds; and this same battery, interposing the body in the circuit, would have no apparent influence upon the same magnet. But to measure more exactly the effect of this resistance, and having a battery capable of so great a range of force, and giving the conductibility of the body the fairest chance, by the employment of large moistened electrodes, we measure different effects upon a galvanometer of fine wire. Our battery is made capable of its quantity range from 1 to 256, and in



intensity from 1 to 150. With the intensity of 1, almost any quantity power will drive the needle to 90°. Through the body no effect is perceptible. We now increase the intensity, until the current passing through the body, drives the needle to 27°. The intensity being the same, we increase the "quantity" from 1 to say 25. The needle advances to 37°. We now use the same intensity, and give the battery a quantity of 256, and the needles sluggishly advance to 47°. Thus, with an increase of quantity power from 1 to 256, we have only slightly increased the effects of the current. The inference is unavoidable. The body refuses to carry these currents, and all other highly resisting conductors follow the same law; and so, for many purposes, we are employing a force vastly in excess of our necessities, and we waste in self-destroying combinations for dynamical electricity, fifty times as much as we make good use of. At the same time, many useful purposes can be served only by the actual use of very great and continued force, and here the small battery exhibited in the engraving would be entirely out of place. A description of it, and the mode of using it, as well as what has been done with it, will prove, however, that it is possible to secure the results we aimed at, as far as regards cleanliness, portability, power, with extreme range of adjustment, freedom from consumption when not in use, and ease in renewal.

The engravings represent glass cells, three inches long, and one inch in diameter, inserted in a wooden block; a zinc cover is provided for each glass, and a projection from this zinc cover, running down into the glass, forms the zinc element. The other element is carbon, carefully connected with platinum, and well insulated from the zinc cover. This cover has a plate of soft rubber interposed between it and the glass top, and the packing is made completely air-tight and water-tight, by the pressure of two rubber springs pulling the cover firmly down. Connection from one cell to the next is quickly made by short pieces of spiral springs. The battery is charged by filling the glasses half full of water, adding some bisulphate of mercury, and a little shred of cloth is interposed between the plates, so as to retain moisture. To use this battery, we invert it, and thus allow the fluid to flow over the plates and saturate the piece of cloth. Restoring the battery, the fluid leaves the plates, though a drop remains in the cloth shred, and in this state, simply from these drops of moisture, powerful intensity currents, producing violent muscular contractions, are given off, and this is the case even forty-eight hours after the immersion of the plates. It is evident that if we can employ these currents, resulting from the simple expenditure of one drop of the fluid, usefully, that we have exhausted a very small portion of the force in reserve, and it is also evident that we can, after use, place the battery out of use for an indefinite time, ready, by the expenditure of another drop of fluid, to give off the desired currents. Properly constructed, we cannot see any reason why the arrangement should not last in good power a year or more for occasional effects; and it can be completely renewed, at the rate of fifty cells in one hour; one hundred and fifty cells exceed in intensity one hundred cells of Grove. The parts are all quickly replaced, no acid is used, and no gas generated.



The second figure shows a modification of the construction. Supposing we wish to employ a fluid of greater energy, but which in decomposition produces gas from which the tight cell must be relieved; we insert a tube through the cover; the opening being just half way down the cell, and the surface of the fluid below. Care being used in inverting the battery, this tube orifice is always in the air space of the cell, whether upright or inverted. When we wish for convenience a battery of large quantity, to be used occasionally, we employ large glasses and elements; but we substitute bolts for the rubber bands, to bind down the zinc covers. An exceedingly convenient battery is thus formed for electric cauterization, where the operation is not too extended. The use of the rubber bands, however, in batteries of high tension, is far preferable to bolts, or their equivalents. The very high insulation of this packed battery is evident from the retention of its power for forty-eight hours and more, where the exciting power is derived from a mere drop of fluid.

# FLAME REACTIONS.

BY PROF. BUNSEN.

Translated by Prof. Charles F. Himes, Ph. D., Dickinson College, Carlisle, Pa.

(Continued from page 200.)

## VIII.—BEHAVIOR OF LEAD COMPOUNDS.

A. *Flame coloration*, pale blue.

B. *Reduction incrustation*, black, dull or brilliant.

C. *Oxide incrustation*, bright ochre-yellow; proto-chloride of tin produces no reaction, also not after the addition of hydrate of soda; nitrate of silver produces no coloration either alone or after ammonia has been blown upon it, or after it has been moistened by it.

D. *Iodide incrustation*, egg-yellow to lemon-yellow, insoluble when breathed upon or moistened; disappears when ammonia is blown upon it, and upon warming it reappears.

E. *Sulphide incrustation*, through brown-red to black, insoluble in sulphide of ammonium when it is blown upon it, or when moistened with it.

F. *On charcoal rod with carbonate of soda*, gives a gray, very soft, ductile, metallic grain, which dissolves with considerable difficulty, though completely, in not too concentrated nitric acid, to a white, easily crystalizable salt, which is soluble in water, and upon the addition of a few milligrammes of sulphuric acid, by means of a capillary pipette, gives a white precipitate.

## IX.—BEHAVIOR OF CADMIUM COMPOUNDS.

A. *Metallic incrustation*, black, with a strong brown coating.

B. *Oxide incrustation*, dark brown, passes through brown into a white, therefore invisible, coating of sub-oxide of cadmium, which is not changed either by proto-chloride of tin alone, or after the addition of hydrate of soda; nitrate of silver on the other hand without ammonia, produces upon it a blue-black coloration of reduced metallic cadmium, which is very characteristic, and does not disappear with ammonia.

C. *Iodide incrustation*, white, not colored with ammonia.

D. *Sulphide incrustation*, lemon-yellow, insoluble in liquid sulphide of ammonium.

E. *Reduction on charcoal rod with carbonate of soda.* The metal, on account of its volatility, is only reduced with difficulty, and incompletely in this way, to a silver-white ductile globule.

### X.—BEHAVIOR OF ZINC COMPOUNDS.

A. *Metallic incrustation*, black, with brown coating.

B. *Oxide incrustation*, white, and therefore invisible. In order to test it, it is rubbed upon a piece of not too fine filter paper, a square centimètre in size, which is moist with nitric acid, and which is then held between two rings of fine platinum wire, three millimetres wide, and burned. If the paper is burned in the upper oxidizing flame at the lowest possible temperature, the ashes form a white, solid film, which can be ignited without fusing, and whilst gently heated appears lemon-yellow, but upon cooling becomes white again. If this film is moistened with several milligrammes of very dilute cobalt solution, and ignited, it appears, after cooling, of a very beautiful green color. It need scarcely be stated, that the same reaction can also be obtained with the metallic incrustation. Proto-chloride of tin, with or without hydrate of soda, as well as nitrate of silver, with or without ammonia, produces no reaction.

C. *Iodide incrustation*, white; not easily recognizable, either alone or after ammonia has been blown upon it.

D. *Sulphide incrustation*, also white, not clearly recognizable, either alone or when moistened with sulphide of ammonium.

E. *Reduction on charcoal rod*, does not succeed on account of the volatility of zinc.

### XI.—BEHAVIOR OF INDIUM COMPOUNDS.

Indium is detected with most ease and certainty by means of the spectroscope. I therefore give the reactions in this place simply for the sake of completeness.

A. *Flame coloration*, intense, pure indigo blue.

B. *Metallic incrustation*, black, with brown coating, at one time dull, at another brilliant. It disappears instantly with nitric acid.

C. *Oxide incrustation*, yellowish-white, scarcely visible; gives no reactions with proto-chloride of tin and silver solution.

D. *Iodide incrustation*, also yellowish, nearly white, invisible, if weak, with and without ammonia.

E. *Sulphide incrustation*, also yellowish, nearly white, scarcely visible, unchanged by sulphide of ammonium.

F. *Reduction with carbonate of soda on charcoal rod*, takes place with difficulty, and affords silver-white, ductile globules slowly soluble in hydrochloric acid.

A summary view of the incrustations of the elements thus far considered, is given in the accompanying table.*

## XII.—BEHAVIOR OF IRON COMPOUNDS.

A. *Reduction on charcoal rod*, gives no metallic grains, or ductile spangles with metallic lustre; the finely powdered metal forms upon the magnetic knife blade a black tuft without metallic lustre; when this is wiped off on to paper, and nitric acid and some hydrochloric acid are dropped upon it, it gives upon warming over the flame a yellow spot, which acquires a deep blue color of Prussian blue when moistened with ferrocyanide of potassium. The original yellow spot moistened with soda solution, and then hung for a few moments in the vessel with bromine vapor, does not give a spot of sesquioxide upon again moistening it with hydrate of soda.

B. *Borax bead*, oxidizing flame,—hot—yellow to brownish-red, cold—yellow to brownish-yellow; reducing flame,—bottle-green.

## XIII.—BEHAVIOR OF NICKEL COMPOUNDS.

A. *Reduction on charcoal rod*, gives, upon pulverizing the charcoal, white, shining, ductile metallic spangles, which form a tuft upon the magnetic knife. The metal gives a green solution upon paper with nitric acid, which, after hydrate of soda has been dropped upon it, and it has been hung in bromine vapor and again touched with hydrate of soda, changes into a brownish-black spot of sesquioxide of nickel. The ashes of the paper, after it has been freed from hydrate of soda by rinsing, can still be used for the reaction with the borax bead.

B. *Borax bead*, oxidizing flame,—dirty violet-gray brown. Upper reducing flame,—gray, on account of metallic nickel, which often unites to form silver-white nickel sponge, whilst the bead becomes colorless.

## XIV.—BEHAVIOR OF COBALT COMPOUNDS.

A. *Reduction on charcoal rod*, gives, upon pulverizing the charcoal, like nickel, ductile, white, shining, metallic spangles, which form a tuft upon the point of the magnetic knife. The metal wiped off on to paper gives, when nitric acid is dropped upon it, a red solution, which, when moistened with hydrochloric acid and dried, produces a green spot, which disappears upon moistening again. The paper with hydrate of soda placed in bromine vapor, and again moistened with hydrate of soda, manifests a brownish-black spot of sesquioxide of cobalt. The reaction is even very evident with a few tenths of a milligramme of metal. The paper, after rinsing off the soda solution, can also be burned and used for coloring the borax bead.

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* The table will be given with the number containing the end of this paper.

B. *Borax bead*, oxidizing flame,—deep blue bead, which does not change in the lower reducing flame. When treated for a considerable time alone, or better still with platin-chloride of ammonium, in the most energetic upper reducing flame, is completely decolorized, but only after long treatment, with the separation of cobalt or platin-cobalt.

## XV.—BEHAVIOR OF PALLADIUM COMPOUNDS.

A. Palladium compounds are reduced upon fine platinum wire, with soda in the upper *oxidizing flame*, to a gray mass, similar to platinum sponge, which, when rubbed in an agate mortar, gives shining, ductile metallic spangles. The spangles, rinsed and dried upon a piece of a chemical flask, dissolve in nitric acid with reddish-brown color. If a small drop of a solution of cyanide of mercury is added to the liquid, a white flocculent precipitate is obtained, which dissolves in ammonia dropped upon it. After evaporation, and boiling with aquia regia, the liquid evaporated to a small drop, gives a dirty orange-yellow, crystalline precipitate of ammonio-chloride of palladium.

B. *Solution of palladium* is colored blue, green, and brown, by proto-chloride of tin, according to the addition of the same.

## XVI.—BEHAVIOR OF PLATINUM COMPOUNDS.

Platinum compounds give, when ignited upon fine platinum wire with soda in the upper *oxidizing flame*, also a gray spongy mass, which, by rubbing in an agate mortar, is converted into shining, silver-white, ductile metallic spangles. These are insoluble either in nitric or hydrochloric acid alone, but with aquia regia give a bright yellow solution, if the platinum is pure; if it contains rhodium, iridium, or palladium, they give a brownish-yellow solution. When solution of cyanide of mercury is added to the solution, and ammonia blown upon it, no white flocculent precipitate is formed, but immediately a bright egg-yellow, crystalline precipitate of platin-chloride of ammonium.

B. Proto-chloride of tin colors solutions of platinum yellowish-brown.

### XVII.—BEHAVIOR OF IRIDIUM COMPOUNDS.

These ignited in the *upper oxidizing flame* with soda, are likewise reduced to metal, which, when rubbed in an agate mortar, forms a gray powder without lustre, and not in the least degree ductile. This is not only completely insoluble in nitric or hydrochloric acid, but also in aqua regia.

### XVIII.—BEHAVIOR OF RHODIUM COMPOUNDS.

These are only distinguished from the iridium compounds by the fact, that the metallic powder, insoluble in aqua regia, when fused with bisulphate of potassa, is partially oxidized, and affords a rose-red solution.

### XIX.—BEHAVIOR OF OSMIUM COMPOUNDS.

These give in the oxidizing flame volatile osmic acid, of a pungent odor, similar to chlorine, and which irritates the eyes.

### XX.—BEHAVIOR OF GOLD COMPOUNDS.

If only traces of gold are present, mixed with a considerable quantity of gangue, it can only be concentrated and detected according to the old process for testing for gold.* Otherwise even a few tenths of a milligramme can be recognized by reduction with soda on a charcoal rod. The yellow, shining, ductile, metallic grain obtained in this way, can be reduced to spangles having the lustre of gold, by rubbing in an agate mortar. These are insoluble in hydrochloric or nitric acid, but give, rather readily, with aqua regia a bright yellow solution. If this is soaked up into a piece of blotting paper, and touched with proto-chloride of tin, purple of Cassius is formed. What remains upon the glass is colored brown by a solution of proto-sulphate of iron, by reason of separated gold, whilst the liquid appears blue by transmitted light.

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* C. F. Plattner's Blow-Pipe Analysis.

### XXI.—Behavior of Silver Compounds.

If silver occurs in traces in slag or complex ores, it can likewise only be detected by the old process, generally employed, of cupellation.*

If the silver compounds are not associated with entirely too large a quantity of foreign matter, even very small quantities can easily be detected by treatment with soda on the charcoal rod. The white, ductile grain of reduced silver dissolves readily in nitric acid, by warming moderately, and with hydrochloric acid, gives chloride of silver, which may be recognized by its behavior toward nitric acid and ammonia. By this reaction, even less than $\frac{1}{10}$th of a milligramme of silver can be detected easily and with certainty.

### XXII.—Behavior of Copper Compounds.

A. *On a charcoal rod, with soda*, copper compounds give a ductile, shining metallic grain, which can easily be recognized by its copper-red color. By rubbing and decantation, metallic spangles are obtained, which can be rinsed, and easily dissolved in nitric acid, in a small glass capsule. The blue solution gives on a strip of paper a brown precipitate, with ferrocyanide of potassium. Instead of using the glass capsule, the solution and testing of the metal can be undertaken at once, upon a strip of filter-paper moistened with nitric acid.

B. *With borax on platinum wire*, give a blue bead, which can easily be converted into a reddish-brown bead of sub-oxide of copper, after the addition of very little binoxide of tin, but not alone. If it is repeatedly alternately reduced and oxidized in the lower oxidizing and reducing flames, it is easily possible to obtain a transparent glass, colored ruby-red by sub-oxide of copper, especially if the reduced bead is allowed to oxidize very slowly.

### XXIII.—Behavior of Tin Compounds.

A. *On a charcoal rod*, the compounds of tin are easily reduced to white, shining, ductile metallic grains. The metallic spangles, obtained by rubbing these, dissolve with difficulty upon a piece of glass, in a drop of hydrochloric acid, and the solution soaked up on to blotting paper, gives a red precipitate with selenious acid, and a black one with tellurous acid dissolved in hydrochloric acid. If a *trace* of dissolved nitrate of bismuth is added to the solution, an excess of hydrate of soda will produce a black precipitate of binoxide of bismuth. The metal when treated with nitric acid, gives white, insoluble binoxide of tin.

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* C. F. Plattner's Blow-Pipe Analysis.

B. *In a borax bead*, which is colored *faintly* bluish by oxide of copper, the smallest traces of a tin compound can be detected with great certainty, since the bead, in the *lower reducing flame*, is colored reddish-brown and ruby-red, as was stated under copper compounds.

(To be continued.)

# HOVER'S CARBONIZED PAPER.

By Hector Orr, Esq.

Read at the Meeting of the Franklin Institute, February 1[illegible]th, 1868

The consumption of paper in the United States, for writing and printing purposes, is enormous; far exceeding the proportion of a similar population in any other part of the world. The demand for printing-paper alone is so immense, that this variety of the article has overshadowed all others, and seems to have nearly monopolized the attention of manufacturers. The selection and preparation of the material, and the finishing of the surface, have drawn out much ingenuity and skill; yet the application of color in the process of printing is a simpler operation than that employed by the smallest school boy in his first lesson in writing. In printing, we place a definite amount of coloring matter, in a state of minute mechanical division, upon a contrasting surface, simply laying the ink on, and leaving it to harden by the slow absorption of its fluid parts.

In writing, however, in addition to all other adaptations, a chemical action is indispensable; we need the contact of both air and light to make the record legible and lasting. Writing with ink, is, in fact, a minute dyeing process, in which a particular color is both produced and fixed by chemical affinity. Yet these conditions seem to have had but little consideration from paper makers. The demand for material has become so urgent that other substances beside linen have been pressed into service. The bleaching salts, made necessary by the use of discolored stock, disturbs the shade of the ink, while the shorter fibre of cotton produces a *piling* on the surface, to allay which various devices have been resorted to, which leave the sheet glassy and almost unimpressible by the ink.

Indeed, when we examine the actual process of paper making, we are surprised at the unlikely means there employed for the desired end. Our paper is literally *felt*, or matted pulp, of several varieties of vegetable fibre,—the natural union of whose particles has been changed by friction and immersion in water, and the material then brought into artificial contact through farther agitation by ingenious machinery, thus interlacing the fibres,—and which, starting at the trough as a wet *cobweb*, by means of heat and graduated pressure, in a few moments ends in finished paper, such as we are all familiar with.

Almost the only difference made by the manufacturer between printing paper and writing paper, thus far, has been the application to the latter of a glutinous wash or sizing, which presents a moderate resistance to fluids, and thus restricts the ink to the exact track of the pen's point, but which, at the same time, causes the ink to stand upon the surface for some time, and while hindering it from spreading, increases the danger of blotting.

On such a substance, so prepared, to find ourselves tracing a fine steel point for hours together without tripping, and *staining in* thousands of delicate characters, each definite and peculiar, is almost wonderful; while the new material employed in pens (a finely sensitive metal), drying and condensing the ink sooner on the pen than on the paper, and requiring a fluid almost colorless when applied, seems to bring the difficulty to an aggravating height. And it is just at this exhaustion of our patience that relief appears in the shape of this CARBONIZED PAPER.

Our writing ink (with trifling variations of proportions), is a compound of sulphate of iron, extract of galls, and gum, held in mechanical union by soft water. When this fluid is applied to the paper, as hitherto made, the following chemical action ensues: the oxygen of the atmosphere forms gallic acid with the tannin of the galls, which, in turn, unites with the iron of the copperas, forming a black precipitate (the per-gallate of iron), and the sulphuric acid, thus set free, enters the body of the paper, while the water passes off by evaporation.

Now this presence of sulphuric acid in the tissue of the paper is not a desirable result. At least it promises no good, and may produce harm. It adds nothing to the permanence of the color, and it may eventually act injuriously upon the very fibre of the paper.

In the Carbonized Paper, however, a new agent is introduced which acts both promptly and powerfully. The carbonate, equally diffused through the whole mass of the paper, is seized on with avidity by the sulphuric acid, forming a sulphate which at ordinary temperature may be considered a permanent compound, while the iron thus suddenly released, unites immediately with the gallic acid, producing the deep, black color so desirable in ink; and the carbonic acid, displaced from the carbonate, may be said to put the sulphuric acid under bonds for good behavior, and yet have no hurtful reaction itself upon either the ink or paper.

It is rarely that we find even a radical improvement on a former practice at once so happily adjust its operation, and carry palpable advantage through all its ramifications.

I have already alluded to the process of letter-press printing as distinguished from handwriting. Printers, hitherto, have had no such assistance in applying their color as this invention offers to the penman; but I am not without hope that it may yet be extended to the art which preserves and promotes all others.

From an earlier period than I can specify, printers have chosen to "work" their paper in a damp condition, having a moderate quantity of water equally diffused through each sheet. In the anxious round of a day's work full of nice practical details, though continued for a lifetime, few will find opportunity or inclination for a philosophical examination of the particular process employed. I have been unable to satisfy myself that this wetting of the paper does anything more than slightly turn back the texture towards its former condition of pulp, raising a minute nap perpendicularly and spreading the fibres horizontally (I have frequently known sheets to spread one inch in twenty-four). Into this new surface the types bury themselves and undergo a slight *wiping* under the pressure, and then when the water is afterwards driven out by evaporation, the fibres knit over the ink, and each sheet also receiving heavy pressure between smooth pasteboards, the nap is laid down, and the ink is thus held mechanically on the paper. This is the best account I can give why our finely printed books do not soil in handling, as a damp newspaper does when fresh from the press.

The public in general is perhaps not aware of the advance in speed that letter press printing has attained in our age. Within my own experience we have passed from five hundred impressions per hour, to *twenty thousand* impressions in the same time from a single surface!

In this rapid movement, we are thwarted principally by the crude mechanical application of color already described. The "second impression" (that applied to the opposite side of the sheet), following so rapidly after the first, that the ink has no time to seat itself in the paper, and hence "sets off" (as we say) on the tympan sheet, which soon becomes soiled and blurs the first impression.

I therefore think that if we could establish a chemical action between the paper and the ink, this grave impediment would be at least abated. We then need apply less color, and that in a more fluid condition than now, and have it adhere more firmly to the surface.

As the process is a Philadelphia invention, I hope our scientific members will spare it a little thought. This is part of my excuse for thus presenting it. I have presumed also a little on the consideration due our old brother printer whose name our Institute has chosen for its special distinction. And here I will leave the matter for the present.

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# METHOD OF QUALITATIVE ANALYSIS OF ANIMAL AND VEGETABLE COLORING MATTERS BY THE SPECTRUM MICROSCOPE.

By H. C. Sorby, F.R.S., &c.

(Concluded from page 205.)

From the Proceedings of the Royal Society, No. 92.

### 20. *Sub-groups.*

Since the narrow absorption-bands are decidedly the most important means of identification, it appears to me that we cannot do better than adopt subdivisions founded on *their number.* We may thus divide each group A, B, and C into sub-groups, in which the neutral aqueous solutions exhibit 0, 1, 2, 3, &c. decided absorption-bands. Sometimes one of them may be so obscure that we may hesitate whether it should be counted or not; but practically this is no very serious objection, if we decide to reckon only distinct bands, and to look on the fainter as important merely in identifying individual colors. If no absorption-band can be seen in the neutral solution, we may take into account those seen when more or less ammonia is added; and if none occur in either case, we may make use of those seen in the alcoholic solution when neutral, and after the addition of ammonia. Whenever in this order of experiments the solution gives any decided absorption-band, the sub-group is determined; and it is only when none is produced that the process must be carried further.

The general connection of the sub-groups will be best seen from the following table:

$$1,\ A \begin{cases} aq_0 \\ aq_1 \begin{cases} am_0 \\ am_1 \begin{cases} al_0 \\ al_1 \begin{cases} am_0 \\ am_1 \\ am_2, \&c. \end{cases} \\ al_2, \&c. \end{cases} \\ am_2, \&c. \end{cases} \\ aq_2\ \&c. \end{cases}$$

The same system is applicable to each division, 1, 2, and 3, and to each group, A, B, and C. We can easily express the sub-groups by using one or more of the signs *aq*, *am*, *al*, *am*, with a figure to indicate the number of bands in the first term that contains any; those before it being given to show the facts more clearly.

Each color can be indicated by writing after the sub-group the characteristic spectrum, or, for the sake of simplicity, merely the position of the *centres* of the bands, when they are seen as independent as possible of general absorption. If the centres of the bands are in different positions the colors cannot be the same; but if they agree it does not necessarily follow that they are the same. It is probable, but must be further proved by the correspondence of other spectra. As examples, I give a few well marked cases.

| | |
|---|---|
| Purple Pansy, . . . . | 1, A, $aq_0$ $am_1$ (4). |
| Crimson Rose, . . . . . . | 1, A, $aq_0$ $am_0$ $al_0$ $am_1$ (2½). |
| Blue Lobelia (*L. speciosa*), . . | 1, B, $aq_2$ (2¾, 4¼). |
| Pink Stock (*Matthiola annua*), . . | 1, B, $aq_2$ (3⅝, 5¼). |
| Several blue species of *Campanula* . | 1, B, $aq_4$ (2⅜, 4, 5⅝, 7¼). |
| Brazil-wood (*Cæsalpinia crista*), . | 1, C, $aq_1$ (5¼). |
| Logwood (*Hæmatoxylum campechianum*), | 1, C, $aq_1$ (4⅜). |
| Sandal-wood (*Pterocarpus santalinus*), | 3, C, $aq_2$ (6. 7½). |
| Alkanet-root (*Anchusa tinctoria*), . | 3, C, $aq_3$ (4¼, 5¾, 7¼). |

## 21. *Individual Colors.*

Having then ascertained to which sub-group any particular color belongs, it is in the next place requisite to determine what particular substance it is. When it gives rise to well-marked absorption-bands, this may be more or less definitely decided by their exact position and character; since they may of course occur in different situations, or vary much in absolute and relative breadth and in intensity. Thus, choosing closely related spectra, we have, for example,—

1, B, $aq_2$
Blue *Lobelia speciosa* . . . $2\tfrac{1}{4} \overset{*}{—} 3\tfrac{1}{4} \ldots 3\tfrac{3}{4} \overset{*}{—} 4\tfrac{5}{8}$ 11 ...

Pink *Matthiola annua*, . . . $2\frac{3}{4}\overset{*}{---}4\frac{1}{4}\ldots4\frac{1}{2}\overset{*}{---}5\frac{1}{2}\ldots8 \quad 10\,..\,11$ — 1, C, $aq_1$

Logwood (*Hæmatoxylum campechianum*), $3\frac{5}{8}\overset{*}{—}5\frac{1}{4}\ldots7\text{--}8$—

Brazil-wood (*Cæsalpinia crista*), . . . $4\frac{1}{2}\overset{*}{—}5\frac{3}{4}\,..\,7\text{--}8$—

Such spectra are at once seen to differ most decidedly when compared side by side; and that the coloring matters are entirely different is proved by other facts. If the absorption-bands agree very closely, we ought to compare other spectra before concluding that the substances are the same.

### 22. *Mixed Colors.*

Of course, if any impurity is present which absorbs that part of the spectrum where the characteristic bands occur, it may be difficult, or even impossible, to determine the nature of the substance; but the rest of the spectrum may be obscured, and the general color entirely changed, without the least difficulty being thereby produced. Thus, for example, on adding a solution of Saffron (*Crocus sativus*) to that of the blue *Lobelia*, the color is changed from blue to a curious olive, and the spectrum becomes—

*Lobelia* and Saffron, . . . . . . $2\frac{1}{4}\overset{*}{—}3\frac{1}{4}\ldots3\frac{3}{4}\overset{*}{—}4\frac{5}{8} \qquad 6\frac{1}{2}\,..\,7$ - —

*Lobelia* . . . . . . . . . . . . $2\frac{1}{4}\overset{*}{—}3\frac{1}{4}\ldots3\frac{3}{4}\overset{*}{—}4\frac{5}{8} \qquad 11\ldots$

Difference . . . . . . . . . . . . $6\frac{1}{2}\,..\,7$ - —

If we did not know it, we might thus infer that they were the same substance, and only differed because one contained a yellow color; and this conclusion would be borne out by adding to each citric acid and sulphite of soda, which make the *Lobelia* colorless, and leave the residual yellow color, $6\frac{1}{2}\,..\,7$ - —, in the case of the mixture. The petals of very many flowers do really contain more or less of such a yellow, which appears to be that developed to a much greater extent in the stamens, &c.; and though this often modifies the general color and the spectra, its presence may be recognized in a similar manner. Different species of *Dianthus*, various kinds of Roses, and *Digitalis purpurea* are good examples of one general coloring-matter modified in this manner. Its normal character is—

$$1,\ \mathrm{A},\ aq_0\ am_0\ al_0\ am_1\ (1\tfrac{3}{4}\overset{*}{\text{--}}2\tfrac{1}{4}\ldots4\tfrac{1}{2}\quad 11\,..).$$

In studying mixed colors, so much depends on their special characters, that it would be difficult to give any other general rules; and particular cases do not form part of the plan of the present paper.

### 23. *Spectra with no bands.*

The principal difficulty to be contended with in this method of qualitative analysis, is in the case of the sub-groups, where no decided absorption-bands can be developed by any of the re-agents. They can be easily divided into the groups A, B, and C, but the difficulty is to distinguish the separate colors, if we are not sure that they are pure and simple. Sometimes special facts may be of use; but, as a general rule, we are compelled to have recourse to the position and character of the general absorption. This requires a good deal of care, since a difference in the state of the solution may make the same color differ more than two quite distinct colors. After trying a number of experiments, I find that the best spectra for comparison are those obtained by adding first a moderate excess of carbonate of soda, and then a considerable excess of citric acid. Both of these solutions change very slowly, and give well-marked spectra; whereas ammonia often causes decomposition, and weaker alkalies or acids give much more faint spectra, or such as rapidly fade. Closely related colors should be compared together, and made as nearly equal as possible after the addition of the carbonate, and then citric acid added in considerable, and nearly equal excess. We thus can compare two different spectra; and even if the position of the absorption is the same in both cases, the relative intensity may vary considerably. Very closely allied colors may often be easily distinguished in this manner, and the only great difficulty is when colored impurities are present. As an example, I give some colors belonging to sub-group 1, B, $aq_0$ $am_0$ $al_0$ $am_0$.

| | Carbonate of Soda. | | Citric Acid |
|---|---|---|---|
| Petals of Wallflower (*Cheiranthus Cheiri*) . . . | 2¼.--.5 | 8..9--10— | 3¾..--..7 |
| Dark grapes . . . . . . | 2¼..--5¾...9 | 10..11-- | 4¼..--..8½ |
| Fruit of Elder (*Sambucus nigra*) . . . . . | 2¼.--6..9 | 11.. | 4½..--..8½ |

The first differs entirely from the latter two, but they are so similar that it requires great care to be sure that they differ essentially. If it were quite certain that such colors were pure, it would not be difficult to distiuguish them with confidence; but since they may contain colored impurities, we must occasionally be content with results somewhat doubtful in questions of minute detail, which might not be of the least importance in some practical investigations.

### 24. *Yellow Colors.*

One of the best general methods of distinguishing yellow colors belonging to sub-group C, $aq_0$ $am_0$ $al_0$ $am_0$, or those with bands which are much alike, is to make them as nearly as possible of the same tint when neutral, and then to add excess of ammonia, which may make them very unequal. For example:—

| | Neutral. | Ammonia. |
|---|---|---|
| Yellow Dahlia (*D. variabilis*) . . | 8 . . 9 - - 10— | 3 ... 4 - - 4½— |
| Yellow Calceolaria (*C. aurea floribunda*) | 7 ... 9 - - 11— | 6¼ . . 6¾ - - 7— |
| Saffron (*Crocus sativus*) . . . . . . | 7 ... 8 - - 11— | 7 . . 8 - - 11— |

The action of ammonia thus shows that they differ very much, but at the same time the *Calceolaria* might be a mixture of the other two, and this would have to be decided by other facts.

### 25. *Fading of Group C.*

Sometimes in examining colors of group C, advantage may be taken of the different rate at which their acid solutions decompose and fade, when a considerable quantity of sulphite of soda has been added to an acid solution. The two solutions should be made as nearly equal as possible in all respects, and then the rate of fading may prove that they are very different, or may show that one is a mixture. After fading, the addition of excess of ammonia may show valuable facts. For example, the color of the root of the red beet (*Beta vulgaris*) is pink, but that of the leaves is red; the spectrum differing from that of the root merely in having the blue end much absorbed. On keeping acid solutions of both to which sulphite of soda has been added, that of the root becomes colorless, and that of the leaves yellow; and thus, considering that acid solutions of colors belonging to group C are very rarely pink, it is almost certain that the color of the leaves is the same as that of the root, but modified by the yellow color so common in leaves.

### 26. *Conclusion.*

Such, then, is a general outline of the method which I have hitherto found the most convenient in studying different coloring matters, and for determining to what individual species any particular color may belong. I need hardly say that it is just the sort of qualitative analysis to employ in detecting adulterations in many substances met with in commerce, as well as in inquiries where very small quantities of material are at command. By this method we might be able in a few minutes to form a very satisfactory opinion, or at least one that might meet all practical requirements, and even under unfavorable circumstances we might narrow the inquiry to a surprising extent; and if this can be said even now, surely further research cannot fail to make it most useful in cases where ordinary chemical analysis would be of little or no use.

# EDUCATIONAL

## THE MAGIC LANTERN AS A MEANS OF DEMONSTRATION.

### MONOCHROMATIC LIGHT.

(Continued from page 208.)

THE difficulty of producing monochromatic light in great quantity, prevents us from demonstrating satisfactorily, many points of interest in connection with the composition of light and the theory of vision. Colored glasses placed in the path of powerful beams of white light, are doubly unsatisfactory; they reduce the amount of light enormously, and with few exceptions (eg. red glass colored with gold), yield a beam of mixed color.

The old experiment of snap-dragon, or the spirit lamp with salted wick, are admirable, as far as they go, but yield a very faint light at best. Something far superior to this is furnished by the arrangement of a ring of cotton wick wound on a wire and supported immediately over and around a large Bunsen burner, the wick being soaked with an aqueous solution of some flame-coloring salt. This plan in effect, is suggested in Sir David Brewster's Natural Magic; but as theBunsen burner was not then known, a less simple arrangement is described to perform the same office.

The drawbacks to this arrangement are, the trouble of adjusting the cotton wicks, the delay in changing to produce a new color, and the brief duration, and to a certain extent, irregular amount of the effect. After lighting, the burners increase their effect to a certain point, and then soon rapidly diminish in the intensity of their light.

When a large number of burners are to be used, these difficulties become serious, and I have therefore devised the following arrangement, which has proved, on trial, thoroughly efficient. The burners to be used, varying in number from 5 to 30 in different experiments, are enclosed below, in a box with a single large entrance, opposite to which is placed an atomizer, operated either by steam or compressed air.

A spray of the coloring solution is thus mixed with the air supplying the burners, and their flames are tinged with the greatest ease, certainty, and intensity of effect, the whole action being entirely under control, and capable of being maintained indefinitely, while the change from one color to another is effected by simply transferring the tube of the atomizer from one solution to another. For experiments demanding diffused light, this apparatus is most satisfactory. Five large Bunsen burners thus arranged, light up the Lecture-room of the Franklin Institute, which seats about 350 persons, and with 60 burners arranged in two groups of 30, I expect to illuminate sufficiently at my next lecture, the Academy of Music, which has 3500 stalls. Of course, in neither case, is the light *brilliant*, but simply sufficient to show in the most distant portions of the room, the peculiar effects of this light on the faces and dresses of the audience themselves. Any object near the flame is, however, brightly illuminated.

The stage being set with the most brilliant scenery and colored decorations, suddenly illuminated by yellow light thus developed, the ordinary gas light being turned down, presents an appearance of ghastly change, which cannot be appreciated until seen, while sufficient light reaches all parts of the house to allow the audience to repeat the observation of strange metamorphosis upon their neighbors.

In certain experiments, however, it is necessary to have monochromatic light of great intensity and concentration.

This I have found could be furnished in the case of yellow light to a certain extent, by substituting in the gas microscope or polariscope, a soda glass rod for the ordinary line cylinder, and so adjusting its position that the rays from the heated glass should be cut off from the lenses, and only the light of the yellow flame should reach them.

We can thus show upon a screen 5 feet in diameter, the greatly increased number of rings developed by a section of Iceland spar, in monochromatic light.

With the spectroscope, we can also project the sodium line on the screen, so as to be well seen by an audience of 500 persons. By afterwards vaporizing a pellet of sodium in a small Bunsen, placed in the lantern and immediately in front of the lime, the black band due to absorption, and its identity in position with the yellow line, is also well exhibited. A full account of these arrangements will be found in this Journal, 1866, Vol. LI., p. 420; Vol. LII. p. 67.

# ON THE FUTURE DEVELOPMENT OF SCIENTIFIC EDUCATION IN AMERICA.

By S. Edward Warren, C. E.

*Prof. of Descriptive Geometry, &c., in the Rensselaer Pol. Inst., Troy, N. Y.*

A great and increasing popular interest in both the general and technical knowledge of the physical sciences, has thus far found expression in the organization, and more or less successful career, of quite a number of institutions, principally devoted to the diffusion of such knowledge.

Institutions of the kind referred to exist, either independently or as parts of more comprehensive organizations, at Hanover, N. H., Cambridge, Boston, and Worcester, Mass., Troy, N. Y., New Haven, Conn., and at Philadelphia, and a few other places, with somewhat various requirements of age and attainments for admission, and with prescribed courses of study, ranging from two to four years in length.

So much having been secured, and the more advanced of these schools having well-established courses of study adapted to qualify young men, of proper ability, for fair engineering, or other like positions, at graduation, with prospect of rapid promotion, the question arises, What further development do these institutions need, and how shall it be secured?

Under the old or "classical" system of liberal, followed by professional, education, the student graduates successively from the Academy, the College, and the professional School of Law, Medicine or Theology.

This progressive order is very generally understood to be a proper one: and it is a generally recognized omission of an important section of one's entire intellectual training, to skip the collegiate stage, as many do, and pass from the academy to the professional school, without the intermediate collegiate training, which is designed to generously develop the *man* before making him a lawyer, physician, or other specialist.

The difference between professional life, which is, and that which is not founded upon collegiate training, *other things being the same*, is this: The former has breadth and general culture and acquirements which fit it to adorn the really best society, and which add finish and lustre to merely professional attainments, and which enable its possessor to bring to bear upon the intricacies of professional study and practice, a mind *already trained to exact and careful thinking.*

The latter, except as native force, ambition, and special diligence may conspire to enable one to cultivate himself liberally, may include but little beyond the routine of a profession, and thus may readily degenerate into a mere trade, in which, through comparative poverty of general mental acquirements, one naturally fails to rise to honorable distinction through the achievement of any notable results.

Such, at least, are the tendencies in the two cases, whatever exceptions may, from time to time, present themselves.

These views lend interest to the inquiry: How shall *scientific* training be so fully developed as to be distributed among a succession of institutions analogous to those which are mainly devoted to literature and abstract logic and philosophy?

We shall probably best find the way to a competent answer, by stating, first, what already *is*, and then what *might be;* first the *real*, and then the *ideal*, of systematic, organized, liberal and professional scientific education. And the former statement shall be made in connection with a parallel exhibition of the successive grades of institutions of the prevailing type.

We are well aware, in doing this, that there are those, doubtless, who question the possibility of a "liberal" education—that is, an effective development of the mental faculties into working powers, by the study, principally, of the mathematics and physical sciences. But we know, also, that many are well persuaded that this development can be secured by such means, and we are, therefore, content, for the present, to quietly assume that every mind, having any *polarity* to its life—that is, having marked preferences for some subjects of thought and research, rather than for others, will *thrive best on what it likes best.*

Only premising, further, what will be mentioned again, that these preferences do not generally manifest themselves decidedly at first, and that, therefore, elementary schools may properly be alike for all classes of minds, we proceed to exhibit, in parallel columns, the two lines of institutions before mentioned.

| | |
|---|---|
| Primary Schools. | Primary Schools. |
| Intermediate Schools. | Intermediate Schools. |
| Grammar Schools. | Grammar Schools. |
| *Latin* High Schools and the Classical Departments of Academies and general High Schools. | *English* High Schools and the department of Modern Languages and Physical Science in Academies and general High Schools. |

| | |
|---|---|
| Purely Classical Colleges, or the classical departments in other colleges. | The "Scientific Course" in colleges having also other courses. Also the first one or two years of some of the *professional* or Polytechnic Schools. |
| Professional Schools of Law, Medicine, Divinity. | Strictly professional schools of Architecture, Civil Engineering, Mechanical Engineering, Mining and Metallurgy, Chemical Technology; or, the closing and strictly professional years of scientific schools, having also a preparatory year or two included in their total course. |

By mere inspection, now, of the second column, the lack of order and unity, through lack of well-defined limitation of the general and the technical or professional grades of scientific education, is apparent.

The "scientific course" running parallel with the "classical" ones in common colleges, and the one or two earlier years in the polytechnic schools, overlap and interfere with each other. And hence it is that so few go through with these "scientific courses," with a view to a *subsequent* professional training in the higher classes of the polytechnic or *professional* scientific schools.

Again, the programmes of the latter schools, however high in theory and practice they may go, are lacking in some features, as compared with the requirements of engineering practice. This arises, first, from inadequate ideas on the part of the public as to the proper composition, breadth and depth of a course of professional training, involving the theory and practice of engineering, or architectural, or mining construction and management. Second, from the partly consequent difficulty of imposing upon students a course of more than four years, not separated into distinct successive divisions.

Classical colleges exist either separately or as separate components of broader or university organizations, in the American sense, of including a circle of professional schools of Law, Medicine, &c. But, in the latter case, there is a well-defined, distinctly-expressed, and well-understood separation between the collegiate course, as preparatory, and the professional schools, as successive, to the former. Now, since the polytechnic or professional schools have to educate the community as to what the depth and extent of the engineering and kindred professions are, they can, at present, at least, probably best do their own preparatory training for themselves.

When the scope and extent of the professions just mentioned are better understood, it may be equally well for the scientific schools to shorten their courses to two, or perhaps three, years of the most elevated and strictly professional instruction; and then, the very elevation of these requirements for admission, accompanied by suitable explanations, would stimulate the development of the "scientific courses" (not professional) in the colleges, and secure the attendance upon them of candidates for the succeeding *professional* schools of science.

But at present, we say we think the latter schools had best include this same preparatory course of general science within themselves, and also resolve themselves, explicitly, into two parts There should be, *first*, the foundation course of general scientific training, collegiate in its spirit and aim—that is, existing to *develope the native mental powers* of the students in it; and, *second*, the circle of truly professional schools, radiating from the general foundation course, as a governing centre and source.

In one or two instances, in this country, this *idea* is realized. It only then remains to *emphasize the expression of it* by a more conspicuous separation of the general from the truly professional stages of the total course of study, and to *amplify it* by adding a year, and raising the requirements for admission till a *cardinal feature* of the *professional* schools shall be lectures upon *higher engineering practice*, by the best experts in the several departments of engineering.

The practical exercises of all kinds, already given in the polytechnic schools, are, in the aggregate, quite extensive, and, in conjunction with an ample body of theory, actually do enable accomplished graduates to enter at once upon very fair professional positions, such as will compare very favorably with those of legal and medical graduates, and such as prove the higher portions, at least, of the instruction given in those schools, to be truly professional. Still, there is room for expansion in the same direction; and though no engineering schools could graduate a *Chief Engineer*, any more than a law school could a *Chief Justice*, yet they might profitably come nearer to qualifying their graduates for controlling positions and independent practice than they now do.

We have, then, the answer to our opening questions. *First.* The programmes of our polytechnic or *professional* scientific schools need to be both elevated and expanded, chiefly in the manner just indicated. *Second.* This result is to be secured by a more complete separation between the foundation general course and the succeeding professional courses growing out of it, and by due adjustment of the conditions of admission.

Having thus rapidly reached this conclusion, let us, even at the risk of some repetition, proceed to discuss it more in detail.

The practical question then returns, how to cause the collegiate stage or grade of educational discipline to be recognized and appreciated in the second column of successive institutions, already given, as well as in the first one? In other words, how shall we dislodge the too prevalent idea that the student may, legitimately and profitably, skip the collegiate grade, and jump from the study of elementary science in the academies, to that of professional science, with all its imperious exactness and multiplied refinements, in the technical school?

Manifestly *not* by *permanently* joining hands between the two classes of schools, through the supplementary giving of elementary instruction in professedly technical ("scientific") schools of engineering, &c., as is now done.

But, on the contrary, by first effectually implanting in the public mind, adequate counteracting ideas, such as are expressed by the above table, of a two-fold system of education, each pursued through a succession of graded institutions, to its crowning conclusion.

Second, by animating these counteracting *ideas* with appropriately elevated *sentiments*, as viz: that to plunge into, and struggle through with, a merely professional training, without bringing to it, or carrying from it, any broad and comprehensive general culture, is to make one's merely professional learning a mere excrescence on an otherwise ill-developed intelligence, rather than as a crowning dome upon the capacious body of a well-proportioned mental structure.

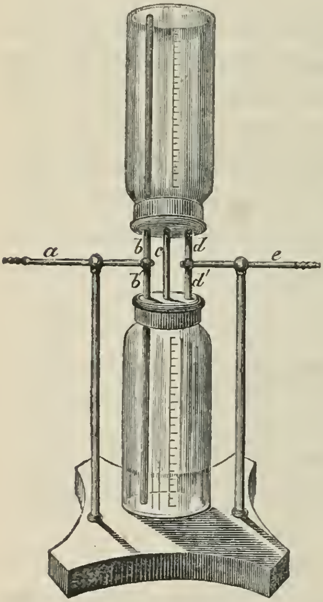
Also, that thus to pursue one narrow line of special study and practice, however far, tends to contract one's sympathies with the great general interests of the race, and to diminish the number of positions in which one can act well among and for his fellow-men. Thence, one's profession itself may, by reason of contracted views, be pursued in the merely trade spirit, or for gainful ends, rather than in the genuine professional spirit of honorable ambition for fame, and of pleasure in doing creditable and beneficent service to man.

(To be continued.)

# GASOMETER FOR ACCURATE MEASUREMENTS.

By Prof. Albert R. Leeds.

A very accurate form of gasometer, especially designed for the measurement of gases while in motion, and for prolonged experiments requiring the estimation of large quantities of gas, has been constructed in the following manner. Two half gallon bottles of fine white glass, and with the widest mouths obtainable, are accurately graduated to cubic centimètres at the standard temperature The divisions are carefully etched upon the sides of the bottles with hydrofluoric acid. A brass cap is cemented upon the top by means of plaster of Paris. The two bottles are placed one above the other, and connected by the system of tubes which is illustrated in the accompanying drawing; *a* and *e* are the entrance and exit tubes, firmly secured down by brass caps to the two wooden supports or pillars. They are corrugated at their outer ends, to allow of a tight connection with India rubber tubes, and closed at their inner ends. Through the upper side of the entrance, and the lower side of the exit tubes, at the distance of half an inch from their closed ends, an orifice is made for the flowing in and out of the gas. Through the caps a brass tube, B B′, passes to the bottom of the bottles. A similar tube, D D′, connected with the exit tube, terminates with the caps. A centre tube, C, passes a short distance beyond the brass plates which form the caps, and then turning back again until it comes almost in contact with the plate, after the manner of a hook, it forms a sort of water valve when the gasometer is in operation, which effectually prevents the escape of water from the upper vessel, except when there is at the same time a supply of gas furnished to it by means of the entrance tube. One of the bottles having been unscrewed from the cap, is filled with clear water, placed back in its proper position, and revolved until it is brought uppermost.



The system is nicely equipoised, and is kept from turning by little pegs let into the base at the sides of the lower vessel. When the gas is forced through the tube, A, it finds an orifice upon the upper and none upon the lower side, and consequently ascends into the top portion of the upper vessel. As it enters, a portion of water of equivalent volume is displaced and runs down through the centre tube. It cannot run through the tube, D, because there is no orifice in the upper side of the exit tube. As the water enters, the gas previously in the lower vessel, not being able to find its way out of the entrance tube, B′, even while for a moment, the end of that tube is not covered with water, on account of the absence of an orifice on the lower side of the main entrance tube, and not being able, moreover, to bubble up through the centre tube, on account of the water valve at at its termination, makes its way through the tube, D′, and the exit tube, E, out into the vessel arranged to receive it. As soon as the water in the upper bottle has fallen to the level of the brass rim, the apparatus is reversed, the entrance and exit tubes serving as pivots to turn upon—and the flow of gas continues without interruption. The usual corrections for temperature and pressure must of course be applied to the volumes read off.

# Franklin Institute.

## Proceedings of the Stated Monthly Meeting, February 19th, 1868.

The meeting was called to order with the Vice-President, Mr. Coleman Sellers, in the chair.

The minutes of the last meeting were read and approved.

The minutes of the Board of Managers were reported by the Actuary, who reported that at their stated meeting on the 12th instant, the following resolutions were passed, viz:

*Resolved*, That the Board of Managers recommend to the Institute that the By-Laws be amended by omitting from the list of standing committees, the committee on exhibitions, as now in section 1st, Article X. And from the list of reports of standing committees, that from the committee on exhibitions, as now in section 2d, Article XII.

The following committees were then appointed by the President:

*Library.*

John C. Browne,
Robert Briggs,
Charles Bullock,
Pliny E. Chase,
Samuel Hart,
B. H. Moore,
H. G. Morris,
Henry Morton,
Percival Roberts,
Samuel Sartain.

*Models.*

James Agnew,
J. Sellers Bancroft,
Wm. B. Bement,
Edward Brown,
Mordecai W. Haines,
Addison Hutton,
John Kile,
Edward Longstreth,
Wm. B. Le Van,
John L. Perkins.

*Arts and Manufactures.*

Wm. Adamson,
John H. Cooper,
Charles E. Foster,
C. Eugene Meyer,
Jacob Naylor,
Hector Orr,
Wm. G. Rhoads,
Jas. B. Sand,
John C. Trautwine,
Henry R. Towne.

*Meetings.*

Henry R. Cartwright,
R. C. Cornelius,
Emile Geyelin,
Robert Briggs,
H. G Morris,
Henry Morton,
Robt. E. Rogers,
Coleman Sellers,
Thomas Shaw,
E. Y. Townsend.

*Minerals.*

Clarence S. Bement,
John C. Browne,
Isaac H. Conrad,
Emile Geyelin,
Robt. H. Lamborn,
Albert R. Leeds,
Theodore D. Rand,
Robt. E. Rogers,
R. A. Tilghman,
Elias Wildman.

*Meteorology.*

Sam'l Allen,
Henry Bower,
Pliny E. Chase,
Chas. M. Cresson,
Lemuel J. Deal,
Jacob Ennis,
Caleb S. Hallowell,
Jas. A. Kirkpatrick,
Benjamin V. Marsh,
Henry Morton.

*Sub-Committee on Scientific Proceedings at Meetings*

R. Briggs, E. Geyelin, Henry Morton, R E. Rogers, and Coleman Sellers.

A paper on carbonized paper was then read by Mr. Hector Orr.

Mr. Robert Briggs then made some remarks upon the structure of domes, after which some remarks were made Mr. H. R. Campbell, on railways for inclines.

The Secretary's report on Novelties in Science and Arts was read, after which the meeting on motion, adjourned.

Henry Morton, *Secretary.*

# Bibliographical Notices.

*Micro-Chemistry of Poisons.* By Theo. G. Wormley, M. D.

A book elegant in binding, paper, typography, and illustrations. The latter were drawn on steel by the accomplished wife of the author. Their beauty is such as to excite comment upon the first glance, but it is not until they are critically examined through a strong lens, that their perfection of finish and detail is appreciated.

Plate 1 gives the crystaline forms of the precipitates obtained with potash and bichloride of platinum, tartaric acid, and tartrate of soda, and of potash, ammonia and soda with carbazotic acid. Plates II. to VI. are devoted to the reactions of the other inorganic poisons. Sulphuric, hydrochloric, phosphoric, arsenious, arsenic acids, the salts of mercury, lead, zinc, &c., and the remaining seven plates to the minute crystals afforded by nicotine, morphine, strychnine, brucine, and the alkaloids in general, when submitted to the action of various reagents. The amounts tested vary from the one-twenty-fifth to the one-ten thousandth of a grain, and are exhibited under magnifying powers ranging from forty to two hundred and twenty-five diameters. Unfortunately the crystaline form is not stated in words, except in a few cases previously well known. It is not essential in a work of this description, it might be said, and the determination of these very difficult matters might well be left to an independent work on micro-crystalography. It is very much to be hoped for, that such a work should be written, as it is highly probable that the microscope will become a powerful instrument of research in chemistry.

Next in interest to these plates, are the numbers which are given to exhibit the limits at which the quantities of the poison present, cease to be capable of detection by the tests employed. They appear to have been determined in a very conscientious and painstaking manner. The ten-thousandth part of a grain of the poison is frequently much more than is sufficient for its detection, and the hundred-thousandth is sometimes ample. The instances of poisoning, cited from various authorities, are selected with discrimination, presented with critical care, and are designed to indicate the action of various quantities under divers circumstances, and in the cases of persons of widely different ages. The symptoms observable are fully given, and also the periods during which the action may be postponed, delayed by the presence of other bodies, protracted, and at which death usually ensues. The smallest quantities which have proved fatal, and the largest amounts which have been taken without producing death, are carefully stated. The medical jurist will object to the book, that it contains many confusing scientific details; the physician, that it has too much qualitative and quantitative analysis; and the chemist, that it has not only the pathological and physiological effects of poisons, but a great deal of their general chemistry, which is more fully stated in other works. But the design of the author has been to address as large a number of readers as possible, and to write a moderately complete treatise, and his aim has been attended with success. A. B.

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*An Elementary Treatise on Heat.* By Balfour Stewart, F. R. S. Oxford: Clarendon Press.

The present work is not characterized by that thoroughness which we should have expected in a treatise especially devoted to the subject of heat, and many matters of secondary importance are omitted, the introduction of which would have rendered it more complete. In the first chapter, upon thermometers, there is no mention made of the maximum and metastatic thermometers of Walferdin, nor of the first air thermometer, that of Sanctorius. Neither is the process given for calculating the size of the reservoir of a mercurial thermometer, and the method for determining the length of each degree is inaccurate. The names of Lavoisier and Laplace might properly have been mentioned in connection with the determination of specific heat by the method of fusion with ice. The process for calculating the specific heat of gases would not have been out of place, even in an elementary treatise, nor a fuller statement of the remarkable results obtained by Person. The chapter on the History of the Steam Engine is superficial. It presents more fully, however, than previous text-books, the relations of heat to electricity, magnetism, chemical affinity, mechanical effect, &c., the subject of exchanges of heat, the mathematical conception of thermal conductivity, and the theories of the "conservation of energy" and the "dissipation of energy" as exemplified in thermal phenomena.

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*Anthracite and Health.* By George Derby, M. D.

The above title heads a small pamphlet of 46 pages, being a paper read before the "Boston Society for Medical Improvement." A short history of the introduction of anthracite into common use is given in the first few pages, when its deleterious effects are discussed, and the results of experiments during the months of January and February, 1868, in seven buildings heated in various ways, with a view of determining the relative humidity, are given.

These results are not only very curious, but very instructive, and are well worth perusal.

# JOURNAL

OF THE

# FRANKLIN INSTITUTE

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FOR THE

PROMOTION OF THE MECHANIC ARTS.

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Vol. LV.] MAY, 1868. [No. 5.

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# EDITORIAL.

## ITEMS AND NOVELTIES.

**The New Railway Bridge at India Point, Providence, R. I.**—It was decided about forty years ago to replace the old bridge near this point, which had become, from the combined effects of age and wear, exceedingly dangerous.

In June of 1866, soundings were made to ascertain the nature of the river-bed, the depth of water, &c. A good solid bottom was found, consisting of gravel, covered with a layer of mud, on top of which is a crust of oyster-shells, forming the river bed. The work then was discontinued until June of '67, when operations were again commenced. After carefully sounding the bottom in the places where the piles were to be sunk, no obstructions were discovered with the exception of the stump of an old pile, which was removed by the divers.

On account of the soft, muddy layer of several feet in thickness, which covers the solid bottom, it was deemed impossible to drive the piles from the ordinary pile driving scow. It was finally decided, therefore, to erect temporary platforms in places where the piles were to be driven. The construction of the platform was as follows: piles were driven in four rows, about twenty feet into the bed of the river, and about nine feet apart; these piles were capped with hard pine, about thirteen inches square, and then covered with spruce plank. This formed a substantial platform, upon which all the heavy work, such as driving the piles and cylinders, was performed.

The permanent piles are arranged in clusters of twelve for the two piers west of the draw, and also two groups under the draw contain the same number. The other groups, five in number, each contain nine piles.

The piles were driven in the following manner: the first pile driven in was sharpened on all sides, the bevel commencing about eighteen inches above the lower end, and the end left about four inches square; all the remaining piles that presented only one side to those already driven, were sharpened only on one side, and the corner piles and those that were in contact with other piles, were sharpened upon the two opposite sides.

The piles are encased in cast iron cylinders driven over them, the space between the piles and cylinders being firmly packed with concrete; the diameter of the cylinders west of the draw is six feet; the other five feet. The castings were made four and a half feet long, one and an eighth inches thick, having a flange four and five-eighths inches wide. The weight of the sections as they came from the moulds, was for those six feet in diameter, 5459 pounds, and those five feet in diameter, 4360 pounds.

The rough castings were covered with a coating of cement, which attached itself firmly to the rough scale, thus forming a solid, durable covering, the sections were then firmly bolted together and carried by a scow to the platform upon which they were hoisted, and from there forced down over the piles by means of a powerful screw-press. Notwithstanding the immense pressure brought to bear upon the cylinders, they were unable to penetrate the solid crust of oyster shells at the river-bed; the crust was then broken up by driving piles all around, and the cylinder again lowered; its weight alone, this time, carried it about four feet into the crust, and upon piling about ten tons of iron together, with continued rocking (accomplished by means of levers), the cylinder was finally forced home: all the others were sunk in a similar manner.

The capping of the piers west of the draw consists of yellow pine, that of the draw is formed of oak; the pier upon which the east end of the draw rests, consists of granite, twenty-two feet long, and six feet thick, resting on piles driven to a depth of thirty feet below the river-bed. The draw, notwithstanding its immense weight, is easily turned by one man. The superstructure consists of the ordinary form of Howe Truss.

The first locomotive crossed the bridge February 28th, 1868, since which time the bridge has been regularly open for traffic. From various experiments that have been made, it is found to be exceedingly rigid. A heavy train passing over, causes a deflection in the centre of the spans less than a quarter of an inch.

**The Proposed New Railway in Ontario, Canada,** which has been for some time past the subject of much interest to the mercantile and farming community of the province of Ontario, and which is intended to connect the counties of Bruce, Wellington and Grey with the City of Toronto, has lately given rise to a very exciting debate in regard to the proposed gauge. The regular gauge of Canada is 5 feet 6 inches. The Company proposed making this gauge only 3 feet 6 inches. Much opposition was made to this deviation from the established gauge, but the 3 feet 6-inch gauge gained the point, upon the ground that a 5 feet 6-inch gauge would nearly double the expense per mile. This is an egregious error; the additional expense in first cost is merely nominal, and it is questionable whether the 5 feet 6-inch gauge is not, in the long run, in the wear upon the sleepers, &c., far cheaper than a smaller gauge. The more *practical* reason underlying this decision may be traced to the fact, that the Toronto dealers expect (by having a different gauge) to be enabled to re-ship and re-sell the products in Toronto, instead of their going directly to Montreal.

**A Railway from China to India.**—The columns of *Engineering* have for some time past been replete with discussions as to the practicability of laying a railway from India to China, *via* Burmah. The exploring party who were sent out to survey the route found it impracticable for a railway, except at an immense cost. This project has now, therefore, been abandoned, and the government has sent out a new expedition to open up the old trade route *via* Bhamo and Irrawaddy. The expedition started on the 13th of January, fully equipped, and having a Chinese guide who speaks the Burmese language, and is to act as an interpreter. We shall be on the watch for further information of this interesting and important expedition, and will apprise our readers of their earliest reports.

**The New Suspension Bridge at Niagara Falls,** is very rapidly progressing; the work during the winter was greatly facilitated by a natural ice-bridge having formed directly beneath it, across which the cables and wires were carried with the greatest facility.

**Some Experiments Relative to the Employment of the Electric Light.** By F. P. Le Roux. Translated from *Les Mondes.*

In a preceding article, I have intimated that the voltaic arc, interrupted for a certain short space of time, can re-establish itself spontaneously. The passage of the current depends greatly upon the temperature of the interpolar spaces. As before stated, I have found it possible by means of this fact, to divide the electric light. By means of a distributive wheel, it is made alternately to pass through two electric light regulators, passing between these two at intervals, for example. of the $\frac{1}{20}$th of a second. Under these conditions, the two lights are, and remain perfectly steady.

It has been found advisable in these experiments, to have the carbon points smaller than usual, as the current then passes in a more continuous manner. If they are of square section, they need not be more than 0·157 inches. I am then convinced that if the carbon points can be procured sufficiently small, the electric light may be divided into two with advantage.

Unfortunately, we have been forced to employ carbon made from gas-coke, and the impurities of that material will not permit of its being made as small as it would be desirable to have the crayon. It is probable that if the carbon points could with facility be procured sufficiently small, the application of the electric light would receive a stimulus equal to that it experienced when De La Rive and Foucault substituted the carbon of the retorts for the vegetable carbon of Davy.

It is well to remark that machines, where electricity is produced by motion, from their very nature would be particularly adapted to that distribution we have explained.

I pass now to some experiments of another nature. I have found the electric light to suffer some modifications of the gaseous matters between the carbon points, on the score of color as well as intensity. The employment of oxygen appears to me to offer some marked advantages. Under the influence of a very small jet of this gas, directed transversely through the carbon towards the middle of the interpolar spaces, the carbon is consumed more rapidly on the side which is exposed to the current of gas; these particles then arrange themselves excentrically; the arc is not so much exposed as ordinarily, when it flits about, sometimes on one side, and sometimes on the other, under the influence of the impurities contained in the carbon. In addition to this, the surfaces between which the arc jumps, which are those that furnish the larger part of the light, in place of being normal to the axes of the carbon, are notably inclined to the side opposed to the direction of the jet of gas; by this means they present themselves more directly towards the regions of space which it is proposed to illuminate. The arc is more steady, and the position of the surfaces is more advantageous where the incandescence is greatest; these are the advantages which are procured where a very small jet of oxygen is directed upon the carbon. It offers some inconvenience to the elongation of the flame produced, by the impurities contained in the carbon ordinarily employed, and I again repeat, that all the improvements which can be, in this manner, produced in the electric light, are intimately connected with the production of carbon as pure and cohesive as possible.

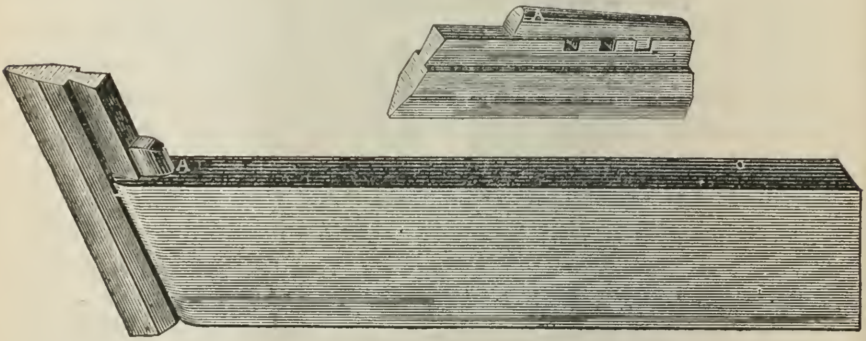
**The Electric Light as Supplied by Magneto Electrical Machines.**—Translated from *Les Mondes*.

Messrs. Jamin & Roger have published an account of some experiments on the electric light, recently made with a magneto electric machine in the physical laboratory established at the Sorbonne, placed there by the *Alliance Company*. It is well known that during one turn of this machine, sixteen currents are produced alternately, in opposite directions, and necessarily separated by a state of repose. The light that this machine produces must then be discontinuous sixteen times during each turn. It is of this intermittance that we now wish to give proof. We have fixed at the end of an axle a silvered mirror capable of turning, and placed at an angle of 45°. The light is thrown upon this from an electric lamp of Foucault's pattern, supplied by a magneto electric machine. The rays are concentrated by a system of lenses, and being reflected by the mirror, are cast upon a screen, where they produce the image of the carbon points. That image describes in the same time as the machine, a circle of light, in which the light appears persistent on account of the rapidity of the movement (500 turns per minute). If the mirror was fixed, the image showed two carbon points one above the other, separated by the arc. As it is moved, the carbon points describe upon the screen two excentric circles, separated at the top and bottom, and intersecting at the extremities of a horizontal diameter; the image of the violet arc is visible only at the top and bottom. One might expect to see sixteen arcs illuminated at the moment of the current's passing, separated by sixteen obscure parts the moment it changes its direction, but it is not so. The image is continued; only there is a slight augmentation in the brilliancy of the violet light of the arc in sixteen prominent positions; while at sixteen other positions the carbons are a little less brilliant, and the arc diminished. The image of the upper carbon was always the more vivid.

The increase of the luminous intensity shows itself alternately at the top and bottom, as it ought to be, when the currents change their sign.

All this might be predicted. That which appears nevertheless to merit attention, is, that the light of the arc is very small as compared with that which is emitted by the carbon; that which supplies the light during the cessation of the current, and to which the light is chiefly due, is the high temperature to which the carbons are brought.

**A New Lathe Tool,** by Shaw & Justice, of this city. We have at various times called attention to improvements in tools, and especially to the plan of separating the cutter from the stock, by which the great loss of material and time occasioned by upsetting or dressing on the anvil, is avoided.



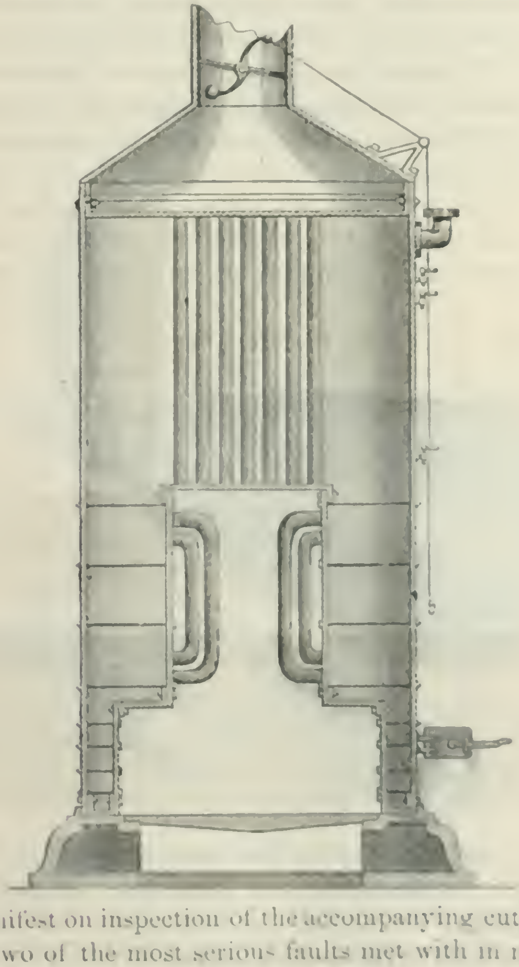
We now give in the accompanying cut, a full view of a new plan for accomplishing this end.

Below is the stock with cutter in place; above, the cutter removed from the stock.

Explanation is hardly required, for anything so self evident as the connection or action of these parts. The cutter is evidently kept in place by the conical wedge, which is secured to it by the sort of tooth and rack adjustment shown; as the tool wears away, it is set higher up by setting the tooth of the wedge back to a further recess in the cutter

The advantages of the arrangement will be evident to every practical machinist at a glance.

**The Excelsior Steam Boiler,** invented by H. T. Fenton. This boiler, whose mode of construction and general principle of operation are manifest on inspection of the accompanying cut, is intended to obviate two of the most serious faults met with in most tubular boilers, namely, incomplete combustion, and imperfect circulation.



The first, it is claimed, finds a remedy in the large combustion chamber provided below the tubes, and the latter is secured by the special arrangement of the tubes shown in the cut, where it is manifest that a rapid up-draft of the heated water and steam will occur in the central portions, an opposite current being established on the outside.

**Glycerine.**—The various uses to which this substance is now applied in the arts, has given rise to competition in its manufacture in this country, and it is now manufactured as pure as it can be imported, and at one-half the cost. In commerce, two qualities of glycerine are found, one of which, applied to irritations on the skin, acts as a salutary balm, while the other, *causes* inflammation and irritation. Recent chemical analysis has shown that the last effect is due to traces of formic acid, and sometimes of oxalate of ammonia.

**A Combined Low Water Indicator and Water Guage,** exhibited at the Monthly Meeting of the Franklin Institute, March 18, 1868, by the Patentee, J. D. Lynde, of 37 N. Seventh St., Philada.

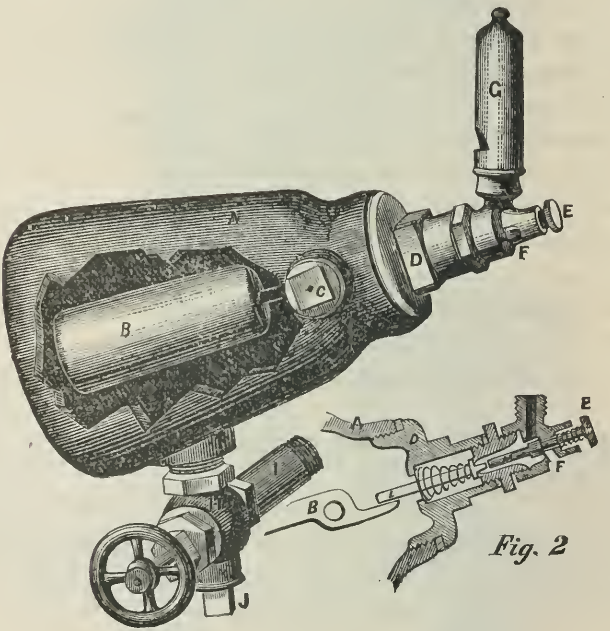


*Fig. 2*

The special merits claimed for this instrument are as follows:

1. Certainty. 2. Simplicity. 3. Durability. 4. Self-detection. 5. Ease of testing. 6. Incapacity to deceive.

These points were explained as follows:—

1. There is no possibility of the working parts sticking from corrosion, as they are daily used as a water-gauge, and consequently are always free. There is double the power required to work the valve, thus placing it beyond a doubt that it will operate *automatically*, as stated.

2. An examination of the cut will show its simplicity. It can at any time be taken apart in a few minutes, and examined for cleaning or repairs.

3. The parts are all made with a view to strength and durability, as an examination will show.

4. It is a self-detector, because, should it get out of order in any possible way, it will show it at once, and require attention.

5. Should it be desired to know if the instrument is in working order, the fact can be ascertained as follows: Shut it off from the boiler, and draw the water from it by unscrewing the plug at bottom; as the water falls out, the valve will be discovered to open, proving it would do the same should the water fall out into the boiler. Close the aperture again, and let in the water. The valve will be observed to be open at first, but as the case fills, it will be found to close automatically, proving that the float has risen to the top of the case.

6. Above all, it will never deceive, as from its construction it must be in *working order*, and faithfully perform its duties, or it will show itself *out of order*, and need attention.

It is believed that this is the only detector which can be employed on a locomotive.

**Experiments with Sound.**—Some interesting experiments in acoustics are translated in the *Scientific American* of a recent date. M. Regnault, of the Institute of France, has been conducting some experiments in the new sewers of Paris, for the purpose of testing, on a large scale, some questions in acoustics, concerning which there has been much doubt.

By firing a pistol in the sewers and in tubes of various diameters, he found that the sound was transmitted through the following distances: In a passage of 4·2 inches diameter, 1282 yards; in a passage 11·8 inches diameter, 4191 yards; in a passage 43 inches in diameter, 10,494 yards. The rapidity with which the sound was transmitted, depended greatly upon the construction of the passage. M. Regnault also discovers that sounds of different pitch are not propagated through these tubes with equal rapidity, but separate from each other on the way. This fact is a new one, requiring study, and experiments are needed to enable us to discover its true reason. We are inclined to believe these results arise from an interference of the waves, and not from the different velocities of sounds of different pitch.

A band of music heard in the open air, at a long distance, still yields a harmony, which shows us that the notes do not reach our ear with a velocity corresponding to their pitch in that case.

**Sulphite of Magnesia.**—In the last number of the *American Journal of Pharmacy*, we find a very good article on the production of the above substance. This salt has not heretofore received any especial attention, but recently having come into request, a search was made in all the authorities for a formula for its preparation. The only formula appearing, was one from Wittstein Jahresschrift, as follows: "Sulphite of Magnesia may be prepared by passing sulphurous acid gas through water, holding carbonate of magnesia in suspension; but the salt thus obtained was not quite white."

"A better way is to dissolve 136 parts of crystallized sulphite of soda, free from carbonate and sulphate, in the smallest quantity of hot water, and to filter into this hot liquid a concentrated solution of 123 parts of Epsom salts, the mixture to be stirred until cold. The mass of fine crystals which form are allowed to drain on a strainer, then pressed and dried at a moderate heat. The product should weigh sixty-nine parts."

The sulphite of soda of commerce is often contaminated with sulphate and carbonate, and if the sulphite was not pure, the yield was diminished in proportion to the impurities contained in it.

The following is the average result of several experiments made by Mr. J. P. Remington, of Brooklyn, and represents about what the results would be in ordinary practice.

Five grammes of Jennings' magnesia (re-calcined), was made into a thick, smooth paste, with ten c. c. of distilled water; to this was added slowly, with stirring, 102 c. c. of aqueous sulphurous acid, sp. gr. 2,037. The liquid on the surface now showed an acid reaction, and had a yellow color; after standing a few minutes, the supernatent liquid was decanted; the crystals were then placed on a tarred filter and washed with distilled water, until the washings came through colorless. The filter and contents were then dried, and weighed 15,310 grammes, which was 306 times the weight of the magnesia used, or

306·2 per cent.; the theoretical yield should have been 3·95 times the amount of magnesia.

The sulphite of magnesia obtained was in small, white crystals, resembling in taste the sulphites, though not so disagreeable as the sulphites of soda and potash, on account of its insolubility. The process was then tried on a somewhat larger scale, with success, but the minutiæ so nearly resembled the former process given, we do not consider it necessary to repeat it. The yellow color seems to be caused by an impurity soluble in sulphurous acid (believed to be iron), and, as it only appears when the acid is in excess, is a good indication that the magnesia has all been acted upon.

By this process, sulphite of magnesia is obtained as pure and white as by double decomposition, with economy in the most valuable items—time and labor; the yellow color all disappearing by the simple process of washing, the loss by washing being small, as the salt is with great difficulty soluble in cold water.

**Metallic Cerium** has lately been prepared by Wohler, in globules of fifty to sixty milligrammes, by the ignition of the double chloride of cerium and potassium with sodium. Cerium when cut and polished, possesses a strong lustre; its color is between that of iron and lead; its specific gravity is 5·5 a 12° c. At the ordinary temperature it slowly tarnishes, while at a high temperature burns explosively, throwing scintillations. At a moderately high temperature it decomposes water slightly, giving off hydrogen.

**Sale of the Late Paris Exhibition.**—The iron portion of the buildings in the Champ Elysées, has been sold to a company of contractors for the sum of $300,000. Its future destination is not yet known.

**Coal in Italy.**—Coal bearings have recently been discovered in Italy, and attempts are being made to work them by means of a joint stock company. The government has ordered fifty tons of coal from the new company, after the completion of certain preliminary experiments.

**The Prevention of Mistakes on Telegraph Lines.**—In the Hughes system, which is so largely in use, many mistakes are liable to occur, sometimes through accident, more often by fraud. The strip containing the message is gummed to a piece of paper, from which the despatch is sent, and can be easily detached and altered. In order to prevent this, the French government have very recently introduced an ingenious method of rendering absolute safety. The despatch after being gummed upon the paper, is passed between rollers having any desired pattern, these impress themselves into the paper, and of course prevent any tampering.

**Philosophical Jewelry.**—We see in *Les Mondes*, a description of a curious invention of M. Trouvé, a clock maker, who has employed electricity in connection with jewelry. The designs shown are scarf pins and brooches, and are worked by small batteries which are carried in a box in the pocket.

Among the most curious is a rabbit, which beats with two drumsticks alternately on a bell; a skeleton head, which moves the eyes and opens the mouth; a grenadier beating a drum; a monkey playing a violin, and a bird, composed of diamonds, whose wings and tail move as in the act of flying.

The batteries used are very minute, and consist of pieces of zinc and platinum, or zinc and carbon, fastened to the lid of the box, while a saturated solution of the acid sulphate of mercury occupies the bottom of the box. When the box stands upright, the elements do not reach the liquid, but when it is inverted or is placed on its side, the action commences, and is communicated to the figure. In the case of the rabbit, the motor is an electro-magnet with a bracket, on which the armature is jointed, a little spring raises the armature, and the commutator, which is on the opposite side, is so arranged that when the armature touches it, the current is interrupted until it returns to its former position, when it is again attracted in the same way. In this way, simple reciprocating action is obtained, which is easily communicated to the arms of the rabbit, causing one to ascend while the other descends. In a similar way, the other figures are caused to move; but for a detailed description of their various arrangements, we must refer to the article in *Les Mondes*.

**Ventilation.**—We were told a few days ago, of a very singular occurrence, which illustrates the fact that even fish know the inconvenience of want of ventilation. A pond in the country was suddenly frozen over without any air-holes, and the fish soon breathed out all the fresh air contained in the water; when some persons chanced to cut a hole through the surface, the fish immediately congregated to it in such numbers and with such eagerness, that they could easily be picked out with the hand.

**Transparent Gelatine Prints.**—At the last meeting of the Franklin Institute, there was exhibited by Mr. Alex. E. Outerbridge, Jr., some transparencies for the lantern, of a novel and effective description. They consisted of impressions from wood cuts, made upon sheets of gelatine *directly from the cut*, and with as much facility as upon ordinary paper. Mr. Outerbridge has since found that the *finest lithographs* may be taken upon this substance with the greatest readiness. The only precaution necessary is to print with a dry stone, since gelatine is very soluble in water. The gelatine may be made insoluble by mixing with it while fluid, a small quantity of bichromate of potash and then exposing to light. This, however, slightly tinges the otherwise perfectly transparent substance. We have in our possession an impression on gelatine, of the map of the Suez Canal, to be found in our last Number. The finest lines and dots appear perfectly, and with more density than could be obtained in a photograph. This opens quite a new and extensive field for lantern illustration.

**Novel Filters.**—Among the novelties exhibited at the last meeting of the Institute, were shown by Professor Rogers some very ingenious filters, brought by him from Paris, consisting of a hollow block of very porous stone or coke, closed by a cork, through which a glass tube, connected with one of India rubber, was inserted. The stone being sunk in the solution which it is desired to filter, and the air being drawn out by the mouth from the other end of the tube, the water or solution then syphons over, and most of the impurity is arrested by the porous substance. It has since been shown by Mr. Alex. E. Outerbridge, Jr., that a like instrument may be produced if we take an ordinary carbon cylinder (a broken piece will answer perfectly), such as is used in the Bunsen battery, and insert a cork in either end of the hole which passes through it, and at one end attach the India rubber tube as before. This form is much more effective than the French syphons, since the carbon is more dense, and therefore arrests the finer particles of mud which escape through the pores of the more open stone or coke used in the French filters. The rate of filtering is of course, however, slower.

**Platina in Oregon.**—A very fine specimen of platina was lately exhibited at the meeting of the "Lyceum of Natural History" in New York, by Professor Chandler. This specimen was brought from Oregon, and weighed over four pounds.

# Editorial Correspondence.

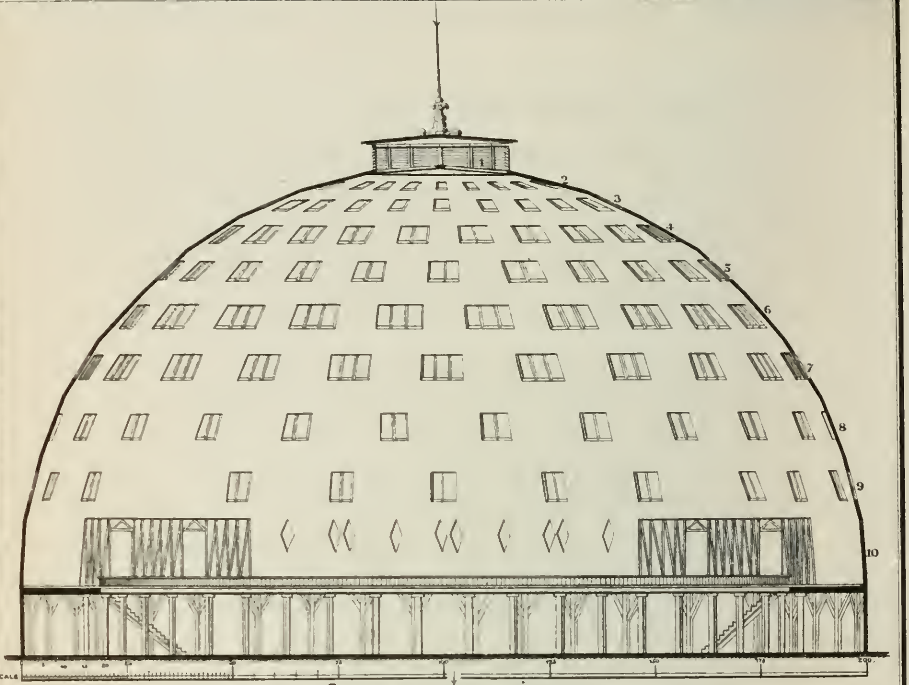
## BRIDGE CONTRACTS.

NEW YORK, *April*, 1868.

THE last two or three years have been remarkable in the engineering world for the great number of large and important bridges that have been begun, and the coming years seem to indicate that very many more will be required to meet the increasing demands of commerce. The West, having the experience of the East for a precedent, is wisely erecting those structures of iron, and the East in turn will replace the gradually rotting superstructures of her railroads with iron ones, being guided by the experience of the West. I do not propose to advocate "iron" as against "wood" as a constructive material, but I do propose to indulge in a few remarks respecting the pernicious practice indulged in by most railway corporations, in the matter of "Bridge Contracts," and more particularly regarding contracts for iron bridges. When an important bridge is to be constructed, the usual custom is to appoint an engineer, who, after examining the ground and selecting the most favorable crossing, advertises in the name of the company for proposals for masonry and superstructure. Of the former, I will say nothing, but concerning the latter, the engineer is rarely competent to design, or even select one as better than another. The consequence is, that the contractor presents his own design with estimates for work, knowing at the same time that the award will be based upon the question of dollars and cents alone. So long as human nature is weak, the temptation to err where money is concerned, is very great, especially in "lumped contracts," and the contractor is tempted to secure the work by reducing the ratio of the working to the breaking load of his bridge to a risky, not to say unsafe degree, but also to buy his iron where he can buy cheapest. It makes a marked difference in a bridge whether one party's bid is based on a ratio of one to four, or one to six, for his working and breaking loads; and when a bid is made upon a basis of a low ratio, coupled with poor iron, we have what insurance companies would call an "extra hazardous risk." I do not say this is so, but I do say that the *tendency* is in this direction, and will be so just as long as railroad companies advertise indiscriminately for a bridge that they may need, and accept any plan that may be presented by a contractor that costs the least. How are they to know that their bridge is properly proportioned in general design, or the carrying out of detail? 'Tis true that they provide a certain test load before accepting a structure from the hands of the contractor, but what does that show in regard to endurance? Mr. Fairbairn's recent experiments upon the import of girders, most effectually show that we must not draw our conclusions from the effect produced by a load a *few times* imposed, but from the *prolonged* action of a changing load. They ask also that their wrought iron should not part under a tensile strain of 60,000 pounds per square inch. So far as this will secure good and suitable bridge iron, they might as well say nothing about the quality of iron. Perhaps there is no material that is more sensitive to variation in manufacture than this essential element of civilization. Its grades, whether cast or puddled, are as different as the furnaces, at which each may be manufactured, dependent on ore, fuel, and method of working. Too much care, therefore, cannot be exercised in its selection for the various purposes for which it may be employed. To most people iron is iron, and an iron bridge is nothing more than its name implies, and one is as good as another. But the metal of which it is built may be cold, short, or red short, common or refined, or all, depending upon where the contractor (who has, nine times out of ten, full discretionary powers as to design and material), could buy his iron the cheapest. That this system is wrong in its tendency, promising disastrous results to life and limb will be apparent to any reflecting man, and unless corrected we will one day have a serious list of disrupted bridges all over the country, which will naturally carry a popular condemnation of iron as a material for bridge superstructure, and a clamor to return to the old perishable wooden constructions. There is but one way for a railway company to secure a *good* iron bridge, and that is to separate contractor and engineer, and have their work designed in all its detail, with rigid specifications as to material, by an engineer engaged and paid for such service, as well as to superintend its erection. Contractors should *all* bid on the *same* plan, which is fair and equitable to each and every one, and the lowest *responsible* bidder can freely be given the work, with every assurance of satisfactory results. Without some such division of labor and responsibility, it seems to me that a direct bid is made for dishonesty, which reacts not only on the parties themselves (for which no one would care a rush), but also imperils the lives of the traveling public, and brings the only proper material for permanent work into disfavor, resulting in its disuse.

Iron, in its various conditions, suitable for various circumstances, is the surest material we can build with, but as before noted, a simple provision in a specification for an extreme breaking limit means nothing. The value of an iron bar in *tension*, is not measured alone by the original unstrained cross-section, but also by the area of the *contracted* section *after parting*, and he who takes the trouble to consult Mr. Kirkaldy's experiments made for the Messrs. Napier, about 1860, will see the importance of this. A high limit, merely shows that the iron is very highly refined, very fibrous and ductile, as in charcoal irons for wire purposes. Lead or copper take a certain strain to part the fibres, which strain is greatly in excess of that when the metal *first* begins to stretch. The moment that point is reached, it is practically gone so far as its further value is concerned. The strength of a metal is reached at the point where the fibres, or molecules, or whatever you choose to call them, refuse to regain their unstrained position. In other words, the point of *permanent set*, inside which limits we can work it with perfect impunity up to one-half or two-thirds (according to service to be performed), the number of pounds or tons causing that permanent set. So that iron should always be specified for its *permanent setting* limit, and not its parting strain. Iron of 60,000 pounds, or over, parting strain, may have a "setting limit," far below an iron that may part at 50, or 55,000 pounds to square inch, and therefore inferior for bridge purposes. I have instanced lead and copper as one extreme, and I now instance steel as the other. Instead of being soft and fibrous, steel is (as compared with iron), hard and granular, and hardly takes a permanent set until almost at its parting strain, and the harder the metal more nearly do these points approximate, until we come to the cast metals, where there is an inappreciable difference between the sectional area before and after tension. Facts like these, familiar as they are to the best iron manufacturers, do not seem to be known as universally as they ought, or if known, they are not acted upon by those who use the material. Far be it from me to accuse railroad presidents and directors of possessing such fundamental knowledge; but they should possess themselves of it, and they would soon understand how an iron bridge may be as unsafe as a boiler, when of bad design and material, which may last and do apparent good service for a few years, and then unaccountably collapse or explode, killing or maiming everybody within reach.

# STRUCTURE OF DOMES



F.2 SECTION OF DOME.

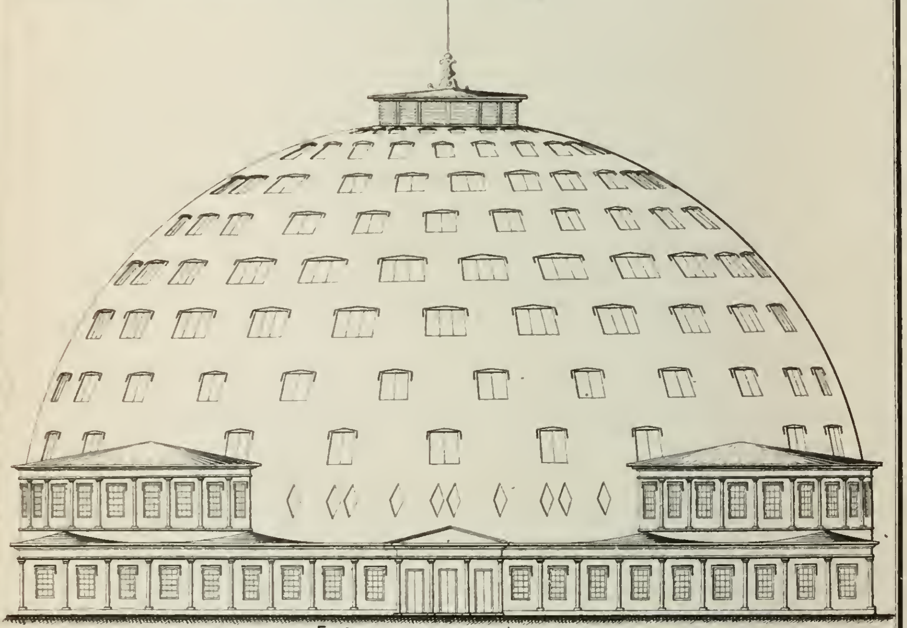


FIG1. ELEVATION OF BUILDING.

Lith. Jas. M' Guigan Philada.

# Civil and Mechanical Engineering.

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## ON THE STRUCTURE OF DOMES.

By Robert Briggs, C. E.

Abstract of a paper read at the meeting of the Franklin Institute, Feb. 19th, 1868

The conditions of equilibrium and stability of domical structures, was the subject of an address at length, with models, diagrams and sketches, by Mr. Robt. Briggs. The following is an abstract of his remarks:

The necessity of providing a suitable building for the proposed exhibition of the Franklin Institute, which should be of large magnitude, to answer the first demand of *purpose*, and of simplicity of construction, with the least material and with that material comparatively uninjured for future use, to fill the second essential *cheapness*, led the speaker to study the availability of a wooden domical structure to ascertain if it were practicable to erect a single dome which should at one span cover the space placed at the disposal of the committee. This space is an area of 208 feet square, within one of the Penn Squares, and the speaker had studied a building consisting of a first story, square in plan, but with a rotunda 208 feet in diameter, constructed within the square, from which a single dome without chords or ties should rise. At the base of the dome would be a gallery of twenty feet width all around the rotunda, and in the corners of the square would be semicircular additions of sixty-one feet diameter upon the level of the gallery floor. The whole giving an area of about one acre on the ground and one-third of an acre upon the second floor.

Figs. 1, 2 and 3, show the elevation, section and half-top view of the proposed building, and Fig. 4 shows a half-top view of the frame-work proposed.

Of course the problem which was to be considered, after devising some detail of construction suited to the magnitude, was the stability of the structure.

The construction proposed after rising upon a collonade to the level of the gallery floor (the strength of which could be readily determined when the load of the dome above was known), was to form a tie-band of boards super-imposed (four layers of one-inch boards being assumed as the method of forming this tie-band), upon which should be stepped the ends of a series of rafters sixteen feet long, three by ten-inch joists; above this would be placed a second band same as the first, and again the second series of rafters would rise from this tie-band similar to the first series. This procedure would be followed ten times, until the tenth series of rafters would meet at the apex of the dome.

The questions then to be solved, was first, the shape most suitable to give this domical structure; and second, after deciding upon any particular shape, to calculate or ascertain the strains upon the tie-bands, and their capability of meeting them, and so far exceeding them as to afford the conditions of stability desirable.

As regards the form, it was possible to take one form which should be so proportioned that no strain should come upon the tie-bands at all, either outwards or inwards, except for the bottom tie-band of all, or some abutment, and any strength or rigidity they should possess, would be the limit of stability of the dome.

Or another form could be that in which the tension upon each tie-band could be made equal, so as to divide the pressure upon all the bands, and not transmit any strain to an abutment.

The adoption of some definite shape, some surface of revolution, ellipsoidal, spherical or similar form, and then to calculate or ascertain in some way, the strains existing at various points of the dome, would be a third way of considering the problem.

In the proposed method of construction, it would be evident that any regular figure possessing uniformity of condition of strains at each and every point, is not to be considered, but that the belts or zones of rafters with circumscribing tie-bands above or below, resolve the problem to one similar to that of a rope loaded at points, in place of that of a cord uniformly loaded. Still it was proper in this part of the discussion, to assume that the uniform load and distribution of strains existed; as the outline of a section of the dome, would in one case be points in a true curve, and in the other the curve itself.

Taking the first form, that of a dome of equilibrium, with the strains upon all the tie-bands, except the lower one, balanced, we have the shape known as a transformed catanery.

The catanery proper is the form of a cord suspended freely from two points, and is that of a suspension bridge or arch, without load, where in the latter case the parts are in perfect equilibrium (and instability), and the entire thrust is transmitted to the abutments. Whatever portion of the same catanery be taken, the horizontal component (or the thrust in case of an arch) is constant.

The transformed catanery which gives the contour of a dome of equilibrium, differs from the ordinary catanery, in that the load upon the chain in place of being uniform, varies as the weights (or areas of surface) of zones of the dome. Like the catanery of a plane, this domical catanery has a constant horizontal component, each and every part of it when considered as composed of pieces made like the stones of an arch, being balanced so far as the tendency to fall in or fall out is concerned, and the entire thrust or unbalanced horizontal component is transmitted from zone to zone to the base of the dome. If we suppose an arch or suspension bridge, it will be recognized that unless we consider the arch-stones or the suspending cord to be a beam, we must expend the thrust of the arch or strain of the cord upon abutments or ties, or upon anchors or straining pieces, which can be most economically and satisfactorily applied at the lower portion of the arch, or the upper one of the cord; but with a domical structure there is nothing to prevent, where it is desirable or practicable, to take up the strain upon bands; using these bands in any portion of the domical surface where strain subsists.

This last proposition leads directly to the second form suggested, that is, one where the unbalanced pressure would be equally divided in all the bands (and if we could suppose the dome to be in perfect contour, the base would rise with a vertical tangent without thrust).

But there are two or three objections to both these shapes: they are very flat upon the crown, so flat that with the least yielding of the material from compression or elasticity, the bearing surfaces of the upper one or two sections, would be impaired, and the whole structure be imperilled—The second form suggested is very open to this difficulty. Again, they have such irregularity of curvature, that it would be difficult to lay out the joints, as each zone differs essentially. Above all, they are very ugly in contour, having neither grace or appearance of repose, which is perhaps the only term by which the evident want of stability beyond the tie-bands or skin can be named. . . . . . . . . . These considerations, with others which were stated, led to the adoption of a hemisphere as a basis for the plan and investigation, and it remained only to devise some approximate means for determining the amount of the various strains upon the polygonal shape which was assumed to construct the hemispherical dome. The data, so far as weights of parts was concerned, could only be approximate, and the information desired as to the strains was also only such an approximation to the actual forces, as would allow a decision of the compatability of the parts with coefficients of safety much greater than any chance of error from the uncertain data or the inaccurate calculations or experimental results.

*The speaker alluded to the difficulties of computation, and the chances of error which lay in considering, as a mathematical problem, these applications of forces to structures, and exhibited a model which had been made to show graphically the results within the limits of accuracy needed. Fig. 5 shows a view of this model.

This model consisted in a chain made of twenty-two links of brass, each four and one-twelfth inches long (sixteen and one-third feet to the scale), delicately hung with little friction at the joints. This chain was suspended freely in front of a drawing-board, upon which was described a semicircle of four feet four inches diameter, the centre line passing through the first joint of the chain, so that twenty of the links hung in contiguity with the semicircle. To each of the links near the middle of its length, where the centre of gravity of the material of the zone which the link represented, was found by inspection and calculation to come, was suspended by a fine wire a weight, which weight represented $\frac{1}{10000}$th part of one-half of the material comprising the zone of the dome. When thus loaded, the ratio of the total weights to the weight of the chain supporting them, was so large that the influence of the chain-weight upon the curve (or polygon strictly speaking) could be overlooked, and the line obtained approximated very nearly to that of equilibrium of a dome composed of conical frustra under the conditions assumed.

If the dome were to be constructed in this shape, the horizontal components at each intersection of the frustra would balance, and

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* It is perfectly easy to compute the strains from the data assumed, in place of obtaining them approximately by a model, but the speaker presented the model as better suited for appreciation to a general audience.

that at the base would be represented by the force needed to draw the upper link into a vertical condition. In the model this force was measured by means of a bell-crank lever, connected by wires to the joint from one end of the lever, and dependent from the other end was placed a weight which counterbalanced the force. The shape of this approximate catenery and the amount of its horizontal component (or parameter) was shown at the meeting. The table which completes this article, gives all the weights employed and results obtained.

In a similar way, by a system of bell-crank levers, the strains which would exist in a hemispherical dome, were resolved into vertical and horizontal components. Each joint in the chain was drawn by a weight into the circle of the hemisphere. The weight required to perform this representing the plus or minus horizontal component, the tension or compression of each tie-band at any point of its circumference.

The following table gives the weight ascertained as that of the separate zones, and the horizontal components which the model exhibited; while the third column shows the strain upon the tie bands, the + indicating compression, and the — indicating tension.

APPROXIMATE HEMISPHERE

| No. of Zone, commencing at crown. | Half weight of timber and skin of each zone. | Horizontal Component ascertained | Strain on tie band. | Total Horizontal Component which the approximate catenary was ascertained |
|---|---|---|---|---|
| 1 | 2,370 lbs. | | | |
| | | 0 | 0 | |
| 2 | 5,920 | | | 14,200 lbs. |
| | | +12,000 | +3,910 | |
| 3 | 10,450 | | | |
| | | +12,000 | +3,910 | |
| 4 | 13,890 | | | |
| | | + 6,400 | +2,040 | |
| 5 | 18,080 | | | Total strain on tie-band at abutment. 14,000 lbs. |
| | | 3,700 | 1,180 | |
| 6 | 21,110 | | | |
| | | 0 | 0 | |
| 7 | 24,850 | | | |
| | | — 8,500 | —2,710 | |
| 8 | 29,550 | | | |
| | | —17,000 | —5,410 | |
| 9 | 32,670 | | | |
| | | —19,300 | —6,140 | |
| 10 | 35,550 | | | |
| | | —14,800 | —4,550 | |

As the weights applied as vertical components by suspension from the links were taken at $\frac{1}{1000}$th part of each balancing half of the total weights of each zone, the horizontal component obtained by experiments could be taken as the force exerted radially upon the tie-band for $\frac{1}{1000}$th part of its circumference, or as so much internal or external pressure applied to the tie-band. The tension or compression on the tie-band consequently was as the ratio of the diameter to the half circumference $\left(\frac{2}{\pi}\right)$, which tension or compression being resisted by both sides of the band, the strain tending to rupture or crush the tie-band, was related to the horizontal component found as $\left(\frac{1}{\pi}\right)$.

The other strains to be resisted in the structure are; that of compression along the rafters; that of the weight of the rafters and skin, which is applied to the rafters as a load upon a beam; and that of the twisting moment which may proceed from some current of air blowing unequally along one side or whirling around the structure.

The strength of the rafters to sustain the load applied to them endways, is too greatly in excess to need question. Their strength as beams supported by their end tie-bands as abutments, is that of ordinary roofs made to carry snows, and intended as permanent structures, the lengths and spaces between being the same.

The arrangement of the rafters incident to the application of the load proceeding from each rafter upon the ends of one or two rafters in the zone below it, gives a system of triangular braces presenting great rigidity. This arrangement may be understood from the following description of the three upper zones: The topmost circle is framed with twenty-four radial rafters stepping on the upper tie-band, the next zone has forty-eight rafters arranged in pairs, the upper ends of each pair supporting the lower ends of the first rafters, and spread at the foot in the form of a letter A, so that between the twenty-four A's, are left spaces with parallel sides for twenty-four windows. The next zone has the rafters similarly arranged, only that under what forms the window spaces in the zone above, the rafters brace like letters M, there being window spaces between each M. Of course these braced triangles

# STRUCTURE OF DOMES

FIG 4 HALF TOP VIEW SHOWING FRAMING

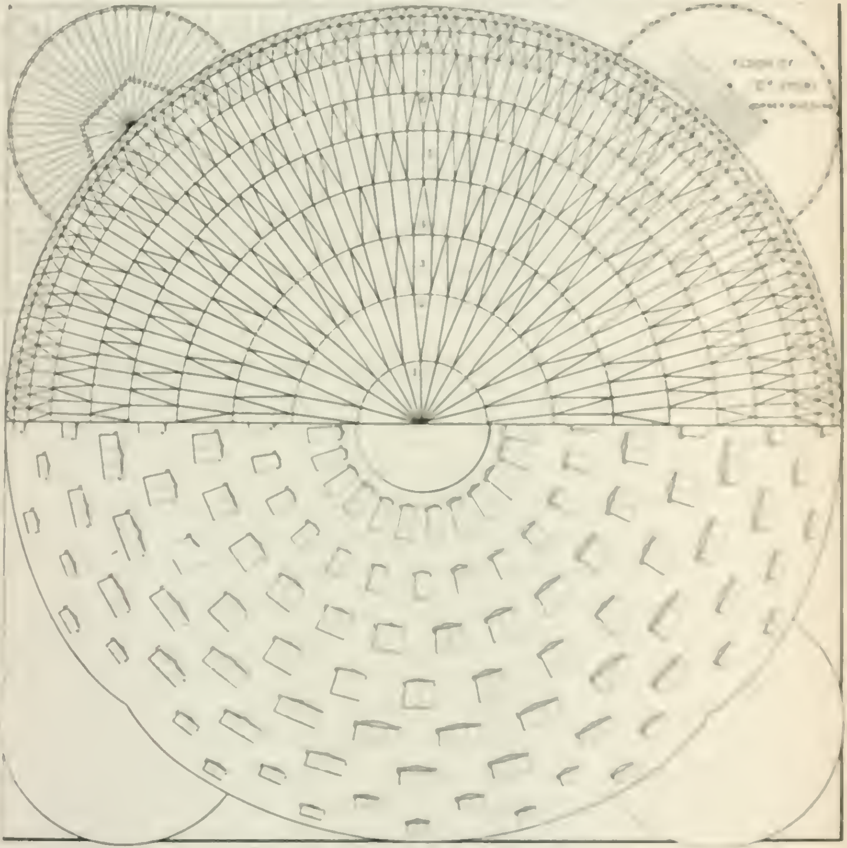
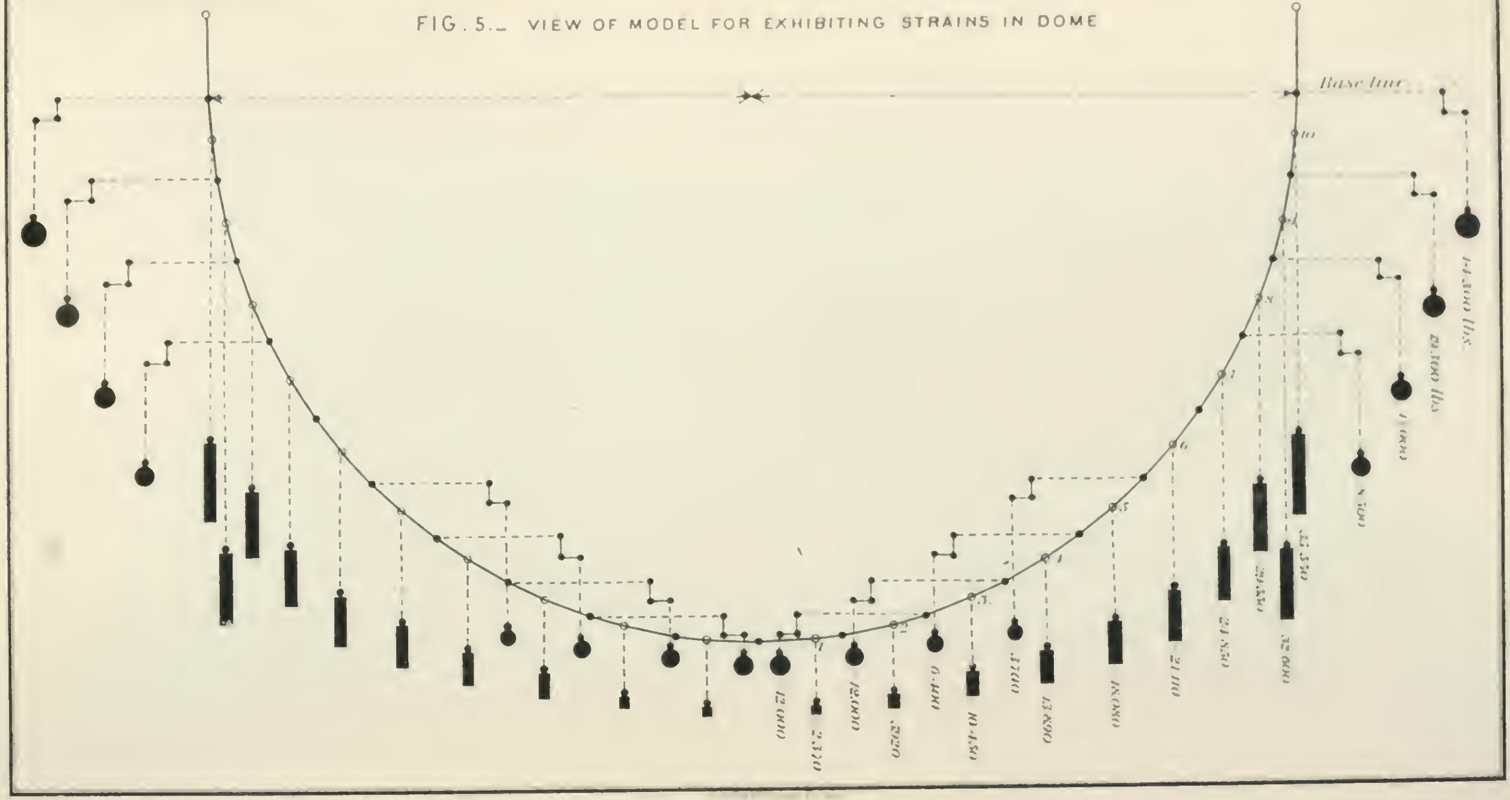


FIG 3 HALF TOP VIEW OF BUILDING

FIG. 5.— VIEW OF MODEL FOR EXHIBITING STRAINS IN DOME



could not be racked except by a force largely in excess of any ikely to be brought against the dome.

The strength of the tie-bands, which are subject to tension, is deived from the ultimate strength of the wood, say 12,000 pounds per quare inch, and by the value of the co-efficient of friction under the loads of weight and thrust. If we take the lower section, for instance, we have in weight about 1000 pounds to each rafter, and there are two rafters to each three feet space, this gives on the sixteen feet length for the tie-band boards, 10,700 pounds load. The friction of wood on wood is quite one-half the weight, where the surfaces are not specially smoothed, and are compressed together so that the contact is not one of points (or splinters). And there are three surfaces of contact (at least), this would show the tensional strength, as derived from the friction between the boards composing it of the lower tie-band, to be from weight alone, 16,000 pounds. The nailings would add to the frictional hold, and the vertical component also aid in consolidating the tie-band. As regards the ultimate strength of the tie-band, it is enormously in excess of any demand. Taking knots, cross-graining and the ends into account, it will be safe to assume that one-half the tie-band, or ten inches by two inches, or twenty square inches section, is sound solid timber, and taking this at one-third ultimate strength, we have 80,000 pounds as the reliable strength.

The discussion of other tensionally strained tie-bands, or of those subjected to compression, would lead to similar results. So far as resistance to winds is concerned, the following considerations may be entertained.

The weight of the dome as proposed, would be about six pounds per foot of surface. From Fresnel's experiments, it would appear that a dome offers about one-third the resistance to wind, that a vertical plane surface presents. Our heaviest wind can be assumed in gusts at eighteen pounds per square foot. The effect upon the dome would be six pounds per foot of section exposed in the direction of the wind.

Reducing this to a pressure all over the surface uniformly distributed, the load is three pounds per square foot, and the effect upon the tie-bands is to increase their strains of tension or compression one-half. But supposing this force is considered as applied, so as to distort, flatten, or *blow* in the dome side, the effect upon all the parts would be more complex. Rafters must crush—bracings must yield—tie-bands must collapse or rend—it would seem that an absolute disintegration, not of the structure into pieces, but of the pieces themselves, must occur before any catastrophe could ensue.

The capability of the whole structure to resist a wind which should move it sideways, can be also demonstrated. Its weight is 400,000 pounds on the first tie-band. The heaviest gust supposable, would exert a force of one-third of eighteen pounds upon 34,000 feet surface, or 200,000 pounds. This would be almost exactly the frictional hold upon a smooth surface, but when the nailings and other sources of adhesion are considered, this ground for alarm disappears.

The strains upon the structure when in process of erection, should not be overlooked. It being needful to demonstrate it could be built as well as that it would stand. After each section is raised and the tie-bands at the upper ends of the rafters attached, it is obvious that the greatest strain to be carried is the tendency of the upper ends to fall inwards, which is to be resisted by the compressive strength of the upper tie-band.

[The lower tie-band of any zone is in all cases only subject to that difference of strain (plus or minus) which exists between the outward thrust of the last section, and the inward thrust of the one below it.]

This tendency can be estimated; for we have the weight of the section W, and the angle $a$, at which the rafters stand, and H (the horizontal component) $=$ W tang. $a$.

By computation, the greatest compressive strain will be on the eighth tie-band, and $=8000$ pounds, which it is abundantly able to carry.

Exteriorly, such a building as proposed would not present striking or graceful architectural features, but within, the expanse would have that grandeur which proceeds from magnitude, and that beauty which comes from apparent lightness. The building would prove an instructive and remarkable portion of our proposed exhibition.*

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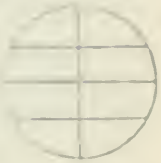
* Although the exhibition itself has been postponed this year, and it is almost certain that this plan would not have been followed, as another less novel and less costly, from its want of novelty, was proposed, it has been thought if not immediately productive, that this study may have some interest.

# TELESCOPIC MEASUREMENT IN SURVEYING.

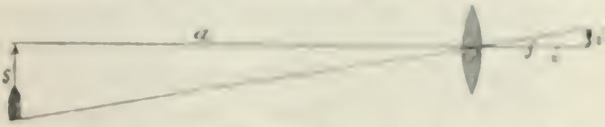
By Benjamin Smith Lyman, Mining Engineer.

Read before the Franklin Institute, at the Stated Meeting, March 18th, 1868.



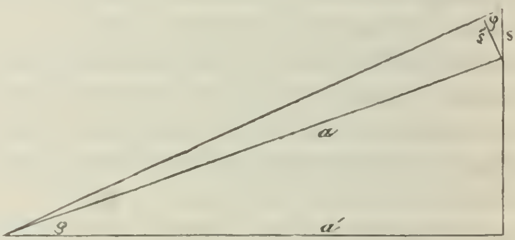
For measuring distances with the telescope, in surveying, the telescope has two or more horizontal cross-hairs besides the ordinary vertical one. In sighting at an upright rod, these horizontal cross-hairs cut off a portion of the rod that is larger or smaller according to the distance of the rod; five times as much, for example, for a distance of a thousand feet, as for one of two hundred feet. A rod graduated to indicate distances in this way, with the help of the telescope, is called a *stadia* by the French, and has been in use some fifty years. In the United States Coast Survey such a rod is called a *telemeter*. The object of this paper is to show that such telescopic measurements in their simplest form are more exact than is perhaps commonly supposed even by professional surveyors; as well as to point out some improvements in the details of the apparatus that add very much to its convenience.

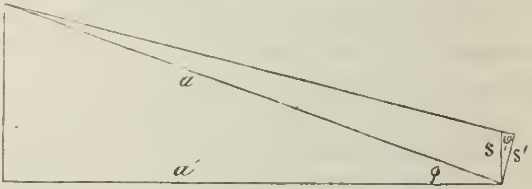
De Sénarmont, nineteen years ago, in the *Annales des Mines* (Fourth Series, vol. xvi.), in a notice of some improved apparatus for telescopic measuring, by Mr. Porro, a Piedmontese, speaks of the stadia as having been used hitherto for rapid and approximate surveys; and gives briefly the theory of its use. If the size of the object seen through the telescope be called $s$; the distance from the object to the centre of the objective $a$; the size of the conjugate image of the object, equal to the distance apart of the two horizontal cross-hairs, $i$; the distance of this image from the centre of the objective $x$; and the focal length of the objective $f$; then, $\frac{a}{x} = \frac{s}{i}$. But the general formula of foci of lenses gives $\frac{a}{x} = -1 + \frac{a}{f}$. Therefore, $a - f = \frac{f}{i} s$; or $a = \frac{f}{i} s + f$. Practically the distance $a$ has commonly been



reckoned so large that the small distance $f$ was neglected, and the formula became $a = \frac{f}{i} s$; in which $\frac{f}{i}$ is a numerical coefficient peculiar to the instrument, and determined by observation once for all. The distances, in that case, are reckoned proportional to the space cut off on the rod, counting from the centre of the instrument, whereas they ought strictly to be counted from a point as far in front of the objective glass as the focal length of that lens.

In case the telescope in measuring is not level, it is necessary to make besides a double correction; because, in the first place, the space cut off on the vertical rod is greater than if the telescope was sighted level; and, in the next place, the corrected distance of the rod in the slanting direction must be corrected again to give the distance reduced to a level. For if $s$ be the space cut off on the rod viewed slantingly, and $s'$ the corresponding space when the rod is held square with the line of sight; if $a$ be the distance of the rod from the telescope in the slanting direction, and $a'$ the correct horizontal distance; and $\varphi$ the angle of the slant with the horizon: then $a' = a \cos \varphi$; $s' = s \cos \phi$; $a = n s'$, where $n$ is the numerical coefficient $\frac{f}{i}$ peculiar to the instrument; and $a' = a \cos \phi = n s' \cos \phi = n s \cos^2 \phi$. It is necessary, then, to multiply the distance indicated by the rod by the square of the cosine of the angle of the sight with the horizon. If, however, account be taken of the necessity, for exactness, of counting the distance $a$ from a point as far in front of the object glass as the focal length ($f$) of that lens; and also

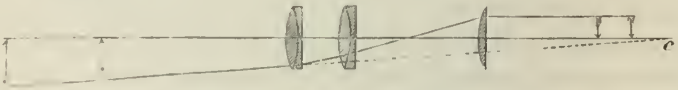




account of the distance of that lens in front of the axis of the instrument, say $d$; then, $a' = (a + f + d) \cos \phi = n s \cos^2 \phi + (f + d) \cos \phi$. But $(f + d)$ is so small a distance, that with the angles common in practice it differs but a trifle from $(f + d) \cos \phi$, and may be reckoned as the same thing: so that, then, $a' = n s \cos^2 \phi + (f + d)$. The quantity $(f + d)$, then, is a small constant, easily determined for each instrument, say one foot or two, that must be added to each level measurement, and to each corrected slanting measurement. Sometimes, when the telescope is not level, the rod is leaned over so as to be square with it; but this is less convenient than the way of correcting just described, for the correction for the slope of the ground has to be made at any rate, and it is extremely easy to make the other at the same time.

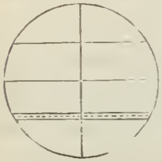
De Sénarmont remarks that experince shows that it is possible to subdivide by guess to a tenth a space that subtends an angle of about sixteen minutes. If, then, the ród when magnified by the telescope subtends an angle of about ten degrees, its length could be marked off in forty divisions, and each of them be subdivided by the eye within a tenth. If, for example, the telescope magnified ten or twelve times, like the ordinary ones on transits, for a range of say 660 feet (ten chains or a furlong), then the rod might be something over thirteen feet long, and be marked with divisions a third of a foot long, and then could be subdivided by the eye within a thirtieth of a foot. This limit of exactness would correspond to a foot and two-thirds of distance on the ground, or $\frac{1}{400}$ of the furlong. But if the telescope magnified twenty times, like the telescopes of levels, the divisions on the same rod could be twice as small, so that the limit of error in the reading of the rod would be twice as small also; and the error in the distance on the ground, therefore, would be not more than five-sixths of a foot, or $\frac{1}{800}$ of the whole distance. This, however, is about the greatest exactness that can be obtained in this way with ordinary glasses; since in this case the magnified rod extends about ten degrees in either direction from the focal axis, and more than that the eye-glass cannot embrace without aberrations that are quite too great; so that, if the power of the telescope be increased, the length of the rod and of its divisions must be diminished in proportion.

Mr. Porro's improvements, then, aim at an increase of the field, and at the same time of the power; and, besides, the distances are made to count from the axis of the instrument. This last change is effected by placing between the focus of the objective and the cross-hairs an additional lens whose focus is at the same point a-the focus of the objective. The rays, then, after passing the added lens are parallel, and all objects that subtend the same angle from a certain point ($c$) behind the objective (a point which he calls the centre of "anallatisme," that is, of unchangeableness, and whose position is determined by the refraction and distances of the lenses) would have images of the same size, and the size of the objects would be proportional to their distance from that centre. The cross-hairs would, then, cut off a space on the rod proportional to the distance of the rod from the centre of unchangeableness, and this centre may be placed at the axis of the instrument; so that the distances found by reading the rod would be counted immediately from that axis, and if they were not level would be corrected, to get the level distance, simply by multiplying by the cosine square of the angle above or below level.

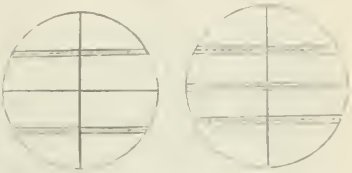


Then, in order to increase the available extent of the field, Mr. Porro used three eye-glasses, which observed the upper, middle and lower parts of the image: so that the cross-hairs could be put farther apart, and by having an eye-glass opposite each one no error would come from the spherical aberration. But, in order to have a sharp and bright image for these eye-glasses to observe, and yet not need a large objective (which would require a focal length at least twelve times as long as the diameter of the lens to avoid excessive spherical aberration), he used two separate achromatic objectives placed one behind the other, that is, a compound lens, such as had long been used for achromatic microscopes and for cameras. By these means he made telescopes of two inches and a third across and only about fifteen inches in focal length, with a magnifying power of sixty or eighty times; and with the triple eye-piece they enabled him to read distances within at least $\frac{1}{2000}$, and so reduced the uncertainty to less than a third of a foot in 660 feet.

More than that, instead of using simply two horizontal cross-hairs, one above and one below, with or without the middle cross-hair, he always replaced the lower cross-hair by two, at one-tenth the distance from each other that the replaced hair would have been from the upper one, making three cross-hairs besides the middle one. Sometimes also he replaced the upper in like manner by two, making five, counting the middle



one; and sometimes he placed two more just above and below the middle, making seven cross hairs in all. These additional cross-hairs serve to show that there has been no material error in the reading, and that the divisions of the rod have been correctly subdivided by the eye, and that the sighting is correct when certain divisions are not distinctly visible owing to obstructions. He obtained in this way, with a magnifying power of sixty or eighty times, and with five cross-hairs, and with the divisions of the rod $\frac{13}{100}$ of a foot (four centimètres) long, an exactness within less than $\frac{1}{2000}$ up to a distance of a furlong; between a furlong and a quarter of a mile the middle cross-hair and two outermost ones, gave an exactness of a good deal less than $\frac{1}{1000}$; and between a quarter of a mile and half a mile, one of the outer pairs of cross-hairs, gave an exactness within $\frac{1}{400}$.



De Sénarmont remarks that such a telescope may be advantageously adapted to geodesical, leveling, topographical or land-surveying instruments; but that, applied to the ordinary compass, to the alidade of the plane table, or to the graphomètre, it would give even with a reduced magnifying power a greater exactness than could be obtained with these instruments for the other elements of a topographical projection; and so some of its advantages would be wasted. He admits, also, that the instrument requires extremely nice workmanship, such as few instrument-makers are capable of: and, although it is possible to test the correctness of the different parts, there appears to be no way of adjusting the position of the cross-hairs without removing them from the telescope.

If, however, the number of horizontal cross-hairs be restricted to three, one above and one below the middle one, they can all easily be made adjustable by screws on the outside of the telescope, if the upper and lower hair be placed a very slight distance before or behind the vertical hair, a distance that can give rise to no inconvenience. Observations with the two upper and two lower of the three cross-hairs, (that is, with all three at once) check each other, and if too little of the rod be visible for that, then two successive observations on different parts of the rod, with either one or both pairs, serve the same purpose. In these ways the lack of Porro's additional cross-hairs is very conveniently supplied, except in the sights that are more than a quarter of a mile long. These extremely rare sights, where even his apparatus claims only the indifferent exactness of $\frac{1}{400}$, it is necessary to give up, and make instead two shorter sights with more exact results.

A convenient way of marking the rod with very small divisions removes the fatiguing necessity of subdividing the divisions by the eye to a tenth, and enables the use of a much weaker telescope. According to Plateau, a red disk lighted by sunlight merely reflected by the clouds can be seen distinctly at a distance equal to 6000 times its diameter; according to Müller, at a still greater distance, especially with a favorable background; but with a telescope magnifying twenty times this distance of distinct visibility, becomes 120,000 times the diameter of the disk. It has already been seen that with a simple telescope of that power, the rod can be at most something over thirteen feet long for a range of a furlong; that is, the length of the rod may be one-fiftieth of the length of range. The smallest visible mark on this rod at the distance of a furlong would be not more than $\frac{1}{120000}$ of 660 feet, say $\frac{1}{182}$ of a foot long. A cross-hair, wherever it should cut a rod divided throughout with such marks, would be within one-half the length of a mark from the centre of one of them, or within $\frac{1}{364}$ of a foot of the reading; and this would correspond to a distance of $\frac{50}{364}$ (less than a seventh) of a foot on the ground. This, then, would be the exactness with such a telescope and such a rod, $\frac{50}{364}$ of a foot in 660 feet, or $\frac{1}{4800}$; and for distances between a furlong and a quarter of a mile the exactness would be within $\frac{1}{2400}$. That is more than twice as exact as Porro's large and complicated instrument with his rod less finely divided; and yet requires no larger field than can be got with a common telescope that magnifies twenty times and has but a single eye piece. A magnifying power of ten times with a rod of the same length would give one-half the degree of exactness at those distances; and the marks on the rod must be twice as large, say, $\frac{1}{100}$ of a foot long. At a distance less than a furlong a smaller space on the rod could be distinguished, but it would be the same fraction of the distance measured, so that the exactness would be no greater.

Such small divisions are readily marked on the rod and made easily legible simply by dividing the feet into tenths, and marking each tenth of a foot with an angular figure, whose angles indicate each a division of one-hundredth of a foot. The rod marked in this way can be used for leveling as well as measuring; and the cross-hairs can be adjusted so that one foot on the rod between the middle and upper or lower cross-hair corresponds to a hundred feet, and the reading gives the distance directly in feet. So adjusted, a telescope that magnifies twenty times uses in measuring just the whole of its available field; but a telescope that magnifies ten times uses only half of it, and is therefore far within the limits set by the spherical aberration of the outer part of the field.

The correction done away with by using the additional lens and reducing the centre of unchangeableness to the axis of the instrument is otherwise made so simply, as already shown, by merely adding to every distance as read from the rod a constant (say, one foot) equal to the focal length of the object glass added to the distance of that glass in front of the axis of the instrument, that the use of those complications seems, on the whole, to have no advantage.

(To be continued.)

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# THE SUEZ CANAL.

By Chas. H. Rockwell.

(Continued from page 242.)

Through one of these shallow basins, called lake Menzaleh, the canal will be dug for a distance of nearly 30 miles. At the end of lake Menzaleh is another smaller basin, called lake Ballah, about 8 miles in extent, as crossed by the canal, and at the southern side of this is found the highest point of land to be seen on the whole line. The extreme width of this ridge, called El Guisr, is about 10 miles, with a summit 61 feet above the sea level, which, added to 26 feet, the depth of the canal, will require a cutting of 87 feet. On the southern side of El Guisr is lake Timsah, through which the canal will be dredged for about 5 miles, it then crosses the ridge of Serapheum, about 8 miles in width, with a maximum cut of 61 feet After this, proceeding southwards, the line strikes the immense basin of the Bitter Lakes, where the level is, in many places, as great as will be required, and where comparatively little work will have to be done for twenty-three miles. This depression is bounded on the south by the ridge of Chalouf, about 5 miles wide, where there must be a cutting 55 feet deep, for a short distance. Between Chalouf and the Red Sea is the Plain of Suez, 10 miles in extent, as crossed by the canal, and elevated only a few feet above the sea level.

The construction of the harbor, or entrance to the canal, at the Suez end, presents no engineering obstacle of any account; the head of the Red sea is so completely land-locked, as never to be troubled with a very heavy swell; there is no current at all; so that it will only be necessary to dredge out a channel into deep water.

At Port Said, the northern terminus, there will be more trouble; nothing, however, which skill and money will not overcome. The harbor here, will be formed by two jetties or piers; the western one extending into the sea for a distance of 3850 yards; say $2\frac{1}{4}$ miles. Its direction being north-north-east, with the extreme end curving a little more to the east. The other pier will extend 2750 yards or a little more than $1\frac{1}{2}$ miles, in a direction nearly north; its base or starting point is 1550 yards eastward from the base of the other, or western jetty; and its extremity will be 440 yards distant from the line of the other; thus giving a clear passage a quarter of a mile wide, into the harbor; which will be the easiest and safest entrance of any of the ports along the eastern shore of the Mediterranean. This triangular area of 575 acres will be dredged to a depth of 30 feet; forming an outer harbor, where vessels can anchor before entering the basins, which communicate with the canal.

These piers were commenced with stone, from the quarries at Mex, a few miles south-west from Alexandria, carried to Port Said in Greek sailing-vessels; but the cost was so great and the progress so slow, that some other mode had to be adopted. The work is now being continued under a contract with Messrs. Dussaud, Freres, who have recently built the harbors at Cherbourg and Marseilles, gentlemen of great experience in hydraulic engineering. The material used in place of stone is a concrete, formed of hydraulic lime, from Theil, France, and the sand which is dredged out of the harbor. The proportions of the mixture are 325 kilogrammes of lime, to one cubic metre of sand; say, 715 pounds to 37 cubic feet. The concrete is formed into large blocks, which measure 11 feet 3 inches in length; 6 feet 7 inches in width, by 5 feet in depth; looking like immense bricks; containing 370 cubic feet each (ten cubic metres) and weighing 22 tons. As we saw them manufactured, the lime and sand were ground together, in large, circular, cast-iron troughs, about 12 feet in diameter; in each trough there ran 3 heavy iron wheels, which completely pulverized the lime, and thoroughly mixed the ingredients. The grinding was continued for about 20 minutes; a small quantity of sea-water being added from time to time, until the mass had assumed the consistency of a thick mortar. A trap-door in the bottom of the trough was then opened, and the mortar fell into a car, standing below. A line of rails guided the car to where the moulds were set up, and into these the mortar is dumped, and carefully rammed into the corners. In about a week's time the concrete has so "set," or dried, as to retain its shape, after the planks and clamps which form the mould, are removed; these are then set up again in another part of the yard. After drying in the open air for about three months, these blocks become hard enough to bear handling without danger of being broken: they are then raised by a steam crane and placed on a car, on which they are conveyed to the dock. Here another crane lifts them from the car, and places them on the deck of a barge, fitted to receive three of the blocks at a time; they rest upon a platform which has an inclination of about 20°, and are retained in their position by iron "fingers," attached to an iron bar, which runs across the lower ends of the three masses. The barge is then towed to the proper position, in the line of the proposed pier, as marked by signal-flags, on shore, and by buoys. When in line, the "fingers" are made to release their hold upon the blocks, and they slide off the barge into the water. After having been submerged for a few months, the concrete becomes nearly as hard as granite. When the accumulation of blocks has approached so near to the surface of the water as to prevent the passage of the barge across the line of the pier, the blocks are lifted from the barge by a floating crane, and deposited in their destined positions, one above another, until the top of the pier is about 15 feet above the surface. There are about 30 of these blocks made per day, and the same number daily submerged. The price paid to the contractors is 400 francs each;* there will be required about 30,000 of them; making the cost of the two piers, twelve million francs. About 10,000 blocks had been sunk up to March, 1867.

There is a very decided current from the west setting along this coast, which brings with it a considerable quantity of sand; this sand fills up the spaces and interstices between the blocks in the piers, thus forming a solid mass, which promises to stand for all time.

It was stipulated by the terms of the detailed concession of January, 1856, from Mohammed Said to Mons de Lesseps, that four-fifths of the laborers to be employed in digging the canal, should be *Fellahs*, or native Egyptians, who were to be furnished by the viceroy in such numbers as might be required by the engineers of the company. They were to be paid by the company at the rate of 12½ to 15 cents per day, (2½ to 3 piastres,) for all laborers over twelve years of age; those under twelve were to receive 5 cents, or one piastre per day, as wages; but a ration for their subsistence to the value of one piastre per day, additional, was to be given to each one irrespective of age. The number of persons thus employed was usually between twenty and thirty thousand; and the principal work on the canal was prosecuted under this agreement from 1859 to 1863. But it was found to be very unsatisfactory in its operation by each of the principal parties. The company could not get the men as they were wanted; they were not easily managed when obtained; and feeling no interest in the general enterprise, they did as little work as possible It was found that eighteen thousand of these laborers, working for ten months, had moved only four million cubic metres of earth; being less than one cubic metre per man per day;* whereas the engineers had calculated that a metre and a quarter would be an easy day's work.† It was found too, that the withdrawal of so many hands from the agricultural force of Egypt was causing a general derangement of its internal affairs; and greatly diminished the amount of taxes received. Still another trouble was, that through the representations of the English ambassador at Constantinople, the sultan was induced to look upon this forced labor of the *Fellahs*, as a form of slavery; and he refused to confirm the concessions of the viceroy, so long as this state of affairs continued. Matters lingered along in this most unsatisfactory condition for two or three years; until in May, 1864, the *Fellahs* were wholly withdrawn from the work. Another article in the concession of Mohammed Said to the company, gave them the right to dig the fresh water canal from Ismailia to Suez, which has been before alluded to. This line was wholly in the desert, a distance of nearly 60 miles through a barren, desolate country, entirely worthless as it then was. The company were also to be allowed to own in fee simple, as much of this waste land as they could reclaim and render fit for cultivation, by means of the water, for irrigation, from the canal which they were to dig. These lands were to be exempt from all taxation for ten years, and

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* About $5·50 per cubic yard.

* 1⅓ cubic yards.

† About six times this quantity is a fair day's work in this country.

after that time, were to pay the same revenue or tax to the Egyptian government, as was imposed on similar lands elsewhere. The company were also permitted to use the fresh-water canal for purposes of transportation, and to receive toll for boats and merchandise passing through it.

It was soon discovered that *water* was all that was needed, to make these sandy wastes really valuable; and the terms for their lease, which the company were prepared to offer, were so liberal, as would speedily induce a large number of French agriculturalists to settle upon them. This caused more trouble and delay at Constantinople; as the English were afraid to have a numerous French colony on the Isthmus of Suez, lest their communication with India should be endangered thereby. The sultan was induced to view the matter in this light, and to withhold his assent from such an arrangement. These difficulties caused a general stagnation in the affairs of the canal company; and for two years their work was almost entirely suspended. The whole subject of the concessions from the viceroy to the company was at last submitted to the arbitration of the Emperor Napoleon, who, in July, 1864, rendered a decision to this effect: 1st. That the concessions of November, 1854, and January, 1856, had the form of a contract, and were binding on the two parties. 2d. That by reason of the withdrawal of the *Fellahs* as laborers, the cost of the work on the canal would be increased; and that the viceroy should pay on that account, an indemnity of thirty-eight million francs to the company. 3d. That the company should cede to the viceroy all of their fresh water canals; reserving only the right of passage through them. And that the viceroy should pay ten million francs for the canals as representing their cost of construction, and six million francs additional, as compensation for the tolls, which the company thereby relinquished. 4th. That the company should retain only such lands along the line of the ship canal, as might be necessary for the proper working and care of it, as a line of passage between the two seas. 5th. That the company should re-cede to the viceroy, their right and title to all lands susceptible of cultivation by means of irrigation from the fresh-water canals; and that the viceroy should pay therefor thirty million francs. This area being estimated at sixty thousand hectares, valued at five hundred francs per hectare; say, forty dollars per acre, for the naked desert. This made a sum total of eighty-four million francs, to be paid as decreed by the

Emperor. The company also agreed to sell to the viceroy, for ten million francs, the "Ouady" property, which they had purchased from El Hamy Pasha. These items, together with the balances due on the company's shares, subscribed for by the viceroy, made a sum total of one hundred and eleven million francs. From this amount there was deducted about nine million francs, as money already paid; leaving a net balance of about one hundred and two million francs still due. Of this, the viceroy paid about twenty-three and a quarter million francs, in 1866; and is now paying at the rate of three million francs per month for this year, 1867. The balance is to be paid at the rate of about one million and a half francs per month, during 1868 and 1869. It is mainly with this money, that the work on the canal is being prosecuted; the required balance being furnished by the share-holders. The total and sudden loss of the *Fellahs*, as laborers, had the effect of retarding the completion of the canal; it being necessary to substitute therefor, steam machinery, and to organize an entirely new system for continuing the work. In this respect there has been the most gratifying success. The principal contract for the excavations along the whole line of the canal, has been awarded to Messrs. Borel and Lavalley, at the price of one hundred and twenty million francs; based upon the estimate of fifty-one million cubic metres of earth to be moved, at two francs, twenty centimes per metre. They agree to have the entire work finished by December, 1869; being stimulated by a large bonus, if completed before that date, and incurring a heavy penalty for each month of delay beyond the time specified. In this immense undertaking, Mons. Borel is the financial manager; and to Mons. Lavalley is entrusted the engineering and executive department. He is a graduate of the "Ecole Polytechnique," and had already shown himself to be one of the first mechanical engineers in Europe, before undertaking this great enterprize. The machines now in use along the line have either been invented by him, as occasion required, or have been especially adapted to do the work in hand. The principal instrument employed, is a large dredging machine, with iron buckets, which are fastened to an endless chain, revolving over two drums; one at the end of a long movable arm, to regulate the depth at which the buckets or scoops shall come in contact with the earth to be excavated, and the other at the top of a heavy frame-work of iron, standing in the centre of the body or hull of the machine. The size of these dredges varies according to the work to be done, and especially as regards the disposition to be made of the excavated material. Those first in use were of very much less capacity than the new ones of later construction. The body or hull of the smaller size is about 83 feet long by 23 feet broad; with the axis of the upper drum 28 feet above the surface of the water. These have engines of 15 horse power, and are capable of excavating about 300 cubic yards of sand per day. The size of the newer dredges was increased from time to time as was deemed prudent, and was warranted by the success of those which had preceded them; the second class having an elevation of 38 feet for their axis, while those of the third class have their drums 48 feet above the water, with their hulls 110 feet long, by 27 feet broad; the material of the hulls in all cases is boiler iron, and in shape they are rectangular. The capacity of these largest machines is equal to 2500 cubic yards per day, of 12 hours, when working without interruption; their engines are of seventy-five horse power. The "prize dredging" for the month preceding my visit, was an average of 1,700 cubic metres per day. The sand when elevated by these dredges is disposed of in one of three ways, according to the position in which the machine is at work. If the earth is required for filling, or is wanted for making of the concrete blocks, it is then emptied into large boxes, holding about 4 cubic yards each, seven of these boxes fit into a barge of peculiar construction, and they are filled by being brought under the spout of the dredge. The barge is then floated to the desired point, where the boxes are lifted from it by a steam-crane and placed upon cars, which run on tram ways in such directions as may be required. One end of the box opens on hinges, so that the contents may be dumped quite easily.

(To be continued.)

# THE U. S. STEAMSHIP "WAMPANOAG."

DURING the late war of the Rebellion, it became the declared policy of our Government, to provide a reliable system of coast-defence, and to rely, for aggression, upon a fleet of vessels of exceptionally high speed, and of comparatively light armament, that should prey upon the commerce of the enemy, while being capable of readily avoiding a conflict with the heavily armed cruisers of the foe.

The *Wampanoag*, one of these American *Alabamas*, has recently made a trial at full speed, and her success may be judged by the report given below.

The greatest speed attained by any foreign naval-steamer is about fourteen and a half knots at the measured mile. From that speed about twenty *per cent.* must be deducted for their speed at sea, say the English authorities. The speed of the *Wampanoag* fleet is therefore several knots higher than that of any naval vessels afloat.

Her "coefficient of performance" is also remarkably high, and she is said to be exceedingly economical in consumption of coal.

Says the British "*Army and Navy Gazette*," of March 13th, "We may well ask, what would *we* not give to have a class of vessels with such a heavy armament, and anything like the speed?"

### REPORT OF THE BOARD OF ENGINEERS.

United States Steamer Wampanoag,
*Hampton Roads, Virginia, February* 17, 1868.

Sir: We have the honor to report, that we have completed the trial of the machinery of the *Wampanoag* at sea, with the vessel driven at the maximum speed, under steam alone, during 37½ consecutive hours; and at the speed of 11 nautical miles per hour, under steam alone, during 25 consecutive hours; the latter performance being to ascertain with what consumption of coal per hour the speed of 11 knots can be maintained at sea.

The average performance during the 37½ consecutive hours of maximum speed was as follows:

| | |
|---|---|
| Average speed of vessel per hour in nautical miles……………… | 16·71 |
| Average speed of vessel per hour in statute miles……………… | 19·265 |
| Average number of the revolutions of the engines per minute | 31·06 |
| Average number of the revolutions of the screw per minute.. | 63·673 |
| Average steam pressure in boilers in pounds per square inch.. | 31·97 |
| Average position of the throttle valves open…………………… | wide. |
| Average consumption of coal in pounds per hour……………… | 12·690 |

There was a fresh breeze abaft the beam, with a moderate sea most of the time on the quarter: the latter part of the trial the sea was heavy. During the above maximum performance the vessel averaged, for 24 consecutive hours, 16·97 nautical miles, or 19·566 statute miles, per hour. During 12 consecutive hours, 16·98 nautical miles, or 19·577 statute miles, per hour; and during 6 consecutive hours, 17·25 nautical miles, or 19·89 statute miles, per hour.

The greatest distance run in any one hour was 17·75 nautical miles, or 20·465 statute miles; the latter speed was obtained and logged four separate half hours, and it is only necessary that the men shall be properly drilled at their duties in the fire-room and coal-bunkers to maintain that speed continuously in smooth water.

The average performance during the 25 consecutive hours, with the intended speed of 11 nautical miles per hour, was as follows:

| | |
|---|---|
| Average speed of the vessel in nautical miles per hour………… | 11·39 |
| Average speed of the vessel in statute miles per hour…………… | 13·13 |
| Average number of revolutions of the engine per minute……. | 21·36 |
| Average number of revolutions of the screw per minute……… | 43·78 |
| Average steam pressure in the boilers in pounds per square inch | 20·69 |
| Average position of the throttle valves open……… ……… | $\frac{9}{10}$ of 1 hole. |
| Average consumption of coal per hour in pounds……… ……… | 3·474 |

There was a light wind and sea ahead for six hours, and a light breeze and moderate sea abaft the beam during nineteen hours of the trial, when it was suddenly interrupted by a gale.

The main valves, gearing, and all other parts of the machinery worked smoothly and in a satisfactory manner, and every journal of the engines, during their entire performance at sea since leaving the navy yard on the 4th instant, worked perfectly cool until the 38th hour of the maximum speed trial, when the crank-pin of the after engine began to warm; the speed of the engines was then reduced by throttling, the first had only time for any requirements of the machinery. The warming of the crank-pin did no injury whatever, nor would it have been the cause of a non-completion of the 48 hours' trial at maximum speed. There was no foaming or priming in the boilers, and the performance of the whole machinery was excellent, and it returned to this port in a condition for any service without requiring repairs.

The maximum performance can be easily maintained during a passage across the Atlantic, or for any required service, and we are of opinion that it is not equalled for speed or economy by that of any sea-going screw vessel of either the merchant or naval service of any country.

Very respectfully, your obedient servants,

THEO. ZELLER,
*Chief Engineer U. S. N.*
JNO. S. ALBERT,
*Chief Engineer U. S. N.*
JOHN H. LONG,
*Chief Engineer U. S. N.*

Hon. GIDEON WELLES,
*Secretary of the Navy, Washington, D. C.*

# Mechanics, Physics and Chemistry.

## LECTURE-NOTES ON PHYSICS.

By Prof. Alfred M. Mayer, Ph.D.

(Continued from page 257.)

### § V. *The General Properties of Matter.—The Constitution of Matter according to the Molecular Hypothesis.*

Matter is that which affects our senses. (See § I).

A body is a portion of matter limited in all directions.

In the different manners in which bodies affect our senses, consist the properties of bodies. These properties are either *general*, that is, belonging to all bodies, whether solid, liquid or gaseous, and therefore come under the head of physics, or they are *special*, and therefore belong to the province of chemistry. (See definitions of Physics and Chemistry, in § I).

Matter possesses several general properties, of which two are called *essential* properties; for without them we cannot conceive of the existence of matter, and therefore they can serve to define it. These two properties are *extension* and impenetrability.

The following is a list of the general properties of bodies:—

| | |
|---|---|
| 1. Extension. | Necessary to our perception of matter. |
| 2. Impenetrability. | |
| 3. Figure. | |
| 4. Divisibility. | |
| 5. Compressibility. | |
| 6. Dilatability. | |
| 7. Porosity. | |
| 8. Mobility. | Ultimate properties according to the molecular hypothesis. |
| 9. Inertia. | |
| 10. Attraction and | |
| 11. Repulsion. | |
| 12. Polarity. | |
| 13. Elasticity. | |

### 1. *Extension.*

Extension is the property which every body possesses of occupying a portion of space, which we call its volume. A body always presents the three dimensions—length, breadth, and thickness: and it is by abstraction only that in geometry we consider *surfaces*, which are the boundaries of bodies, and have only length and breadth: and *lines*, which are the boundaries of surfaces, and have only length; and *points*, which are the terminations of lines, and have alone position.

For the measurements of extension, see § II.

### 2. *Impenetrability.*

The property which every body has of excluding every other body from the space which it occupies.

In ordinary language, we say that one body is penetrated by another, but in all these cases it is found that the particles of the one body are merely *displaced* by the other.

*Examples.* A needle *penetrating* (displacing) mercury contained in a fine glass tube. The mercury rises in the tube, as the needle descends, to an amount exactly equal to what would be produced by pouring into the tube a quantity of mercury equal to the volume of that portion of the needle below the surface of the mercury.

A liquid cannot be poured into a vessel unless the air, which it contains, goes out as it enters.

Consider the images formed in the foci of converging lenses and mirrors; and also a shadow.

We can now define matter as *all that* which has both extension and impenetrability, and therefore void space or *vacuum* is space without impenetrability,—being penetrable.

### 3. *Figure.*

The bounding surfaces of a body give it its figure or form.

That department of science which discusses and classifies the forms of nature, is called Morphology.

The forms of bodies may be arranged under two divisions.

I. *Regular Forms.* II. *Irregular or Amorphous Forms.*

Regular forms can be embraced in two classes (*a* and *b*).

*a. Forms of matter produced by the action of forces not directed by the vital principle.*

1. Forms of the heavenly bodies. Considered in Astronomy.

Forms of liquids in motion; as "the liquid vein;" (see researches of Poncelet, Savart and Magnus), the rain drop; the forms of waves.

Forms of liquid at rest; (not contained in vessels) as the dew-drop; the soap-bubble.

Forms of liquids not subject to the action of gravity; as the forms assumed by oil—suspended in a mixture of water and alcohol of the same density as itself—when subjected to various conditions of molecular action. (See Plateau's *experimental and theoretical researches on the figures of equilibrium of a liquid mass withdrawn from the action of gravity.* Translated in Smithsonian Reports, 1863, *et seq.*

2. Forms of crystals. The laws ruling these forms considered in the science of Crystallography.

*b. Forms of matter produced by the action of forces directed by the vital principle.*

1. Forms of plants. Considered in botany.

2. Forms of animals. Considered in zoölogy.

All the forms of matter not contained in the foregoing classes are irregular or *amorphous*, and belong to class II.

Diagrams illustrating above classification of forms.

### 4. *Divisibility.*

Every body can be divided into many parts, and these parts can be further subdivided until the parts become so minute as to escape observation, even when aided by the most powerful microscopes.

That matter was susceptible of very minute division, was known to the philosophers of ancient Greece and of India, and they discussed the question, whether matter was infinitely divisible, or divisible only to a certain minuteness, when the parts were supposed to be unalterable by any means, whether mechanical or chemical. Mathematically speaking, the division has no limit, for however small the residual particles may be, nevertheless, since they have extension they have divisibility. But we demand not what may be conceived, but what really exists; and in fact, the discussions of the ancients are about the infinite divisibility of space, and prove nothing as to the actual divisibility of matter.

Anaxagoras and Aristotle admitted its infinite divisibility; Leucippus maintained a contrary opinion, and Democritus, siding with Leucippus, gave the name of *atoms* to the ultimate unalterable parts of which he supposed all bodies to be composed. Epicurus attempted to develope the ideas of Democritus, that found in the seventeenth century a zealous defender in Gassendi, whilst Descartes upheld the opinion of Aristotle.

But we have in the phenomena of molecular physics, in the laws of combination in chemistry, and in the facts of crystallography strong evidence that all bodies are composed of ultimate excessively small parts, which are invisible, even with the aid of the most powerful microscopes, but still of finite dimensions, of infinite hardness, unalterable by any means, and separated from each other by spaces which are very great when compared with their size. These parts which are the limits of the possible division of matter, are called *atoms* (Gr. ἀτομος; α privative and τέμνω, to cut.)

According to this hypothesis, a union or grouping of two or more atoms forms a *molecule;* a combination of molecules a *compound molecule*, and a union of the latter a particle.

The sensible division of matter can be carried to a very minute limit.

*Examples.* Gold can be beaten into leaves $\frac{1}{25000}$th of a millimètre thick.

Silver wire, gilded with $\frac{1}{360}$th of its diameter of gold, can be drawn so fine that one mètre weighs only eight milligrammes. The gold film on this wire is now only $\frac{1}{800000}$th of a millimètre thick. By placing a short piece of this wire in nitric acid, the silver core is dissolved out, leaving a tube of gold, having a wall only the $\frac{1}{800000}$th millimètre thick. Now, under the best microscopes, we can discern a surface of $\frac{1}{4000}$th of a millimètre in diameter; therefore we can divide gold into particles $\frac{1}{4000}$th millimètre in diameter, and $\frac{1}{800000}$th millimètre thick; yet each of these parts has all the physical and chemical properties of a large mass, as can be determined by testing it under a microscope.

Dr. Wollaston drew platinum wire so fine that its diameter was only $\frac{1}{1200}$th millimètre ($\frac{1}{30000}$th inch); and although platinum is the heaviest of the metals, yet it took 200 mètres of this wire to equal one centigramme in weight; or, in other words, one mile of this wire weighed about one grain. Dr. Wollaston accomplished this by wire-drawing a cylinder of silver $\frac{1}{5}$th of an inch in diameter, having in its axis a platinum wire $\frac{1}{100}$th inch diameter, and after having obtained a very fine wire—having in its interior a platinum wire of still greater tenuity—he dissolved with nitric acid the silver coating, and thus obtained an almost invisible platinum wire.

The thickness of a soap-bubble, in the dark spot which is formed on it just before it bursts, is $\frac{1}{100000}$th millimètre.

Divisibility of matter in solution. One grain of carmine tinges ten pounds of water, which we can divide into about 617,000 drops. If we suppose that 100 particles of carmine are requisite to produce a uniform tint in each drop, it follows that the one grain of carmine has been divided into 62,000,000 parts.

Metallic solutions and chemical tests.

Illustrations from organized bodies.

The thread of a spider is composed of more than 1000 separate threads.

The diameter of the red disks contained in human blood is $\frac{1}{4000}$th inch; while the diameter of the blood-disks of the Java musk-deer is only the $\frac{1}{12325}$ inch, so that a drop of this deer's blood, such as would adhere to the point of a fine needle, would contain 150,000,000 disks.

It has been calculated that some of the siliceous plates which cover and give rigidity to the minute vegetable cell-plants, called diatomaceæ, weigh only $\frac{1}{200000000}$th of a grain; yet the surfaces of these plates are covered with the most exquisite tracery of siliceous stria or bars, often not more than $\frac{1}{85000}$th inch in width and thickness. Now we can discern a surface of $\frac{1}{85000}$th inch in the best microscopes, and a portion of one of these siliceous disks of that area would weigh only about $\frac{1}{45000000000}$th of a grain.

Divisibility of odorous substances.

A portion of musk will give off a powerful odor during a year, and yet its diminution in weight has not been sufficient to be detected by the most delicate balance.

"In order to offer an inexact idea of the minuteness of the particles of musk which are still capable of imparting some odor, we state, after a well known experimenting physiologist, that a certain liquid, containing as much of an extract of spirit of musk as $\frac{1}{2000000000}$th part of its whole weight, was at this time still distinctly odorous. A grain's weight of a liquid of which $\frac{1}{2000000}$th part was of that extract, spread an intensely penetrating odor. Next after musk are to be mentioned certain flower ethers, especially the oil of roses, a little drop of which is sufficient to fill with odor an immense atmosphere. The same physiologist states that a certain space filled with air, of which, at the highest, only $\frac{1}{1000000}$th part was vapor of oil of roses, still diffused a distinct odor of roses." See article "On the Senses," in Smithsonian Report, 1865.

### 5. *Compressibility.*

All bodies when subjected to exterior pressure are reduced in volume, and since all bodies can thus be indefinitely compressed, it follows that the matter of which bodies are composed does not fill the space which is contained within their bounding surfaces: or, as it is sometimes stated, a body does not form a *plenum* of matter.

The compressibility of solids is seen in all structures and machines where matter experiences great pressure; *e. g.* The stone pillars which support the dome of the Pantheon, at Paris, sensibly diminished in height as the weight which they bear was placed upon them, and a visible depression takes places in the arches of massive bridges when the "centres" are knocked away.

The relief of coins and medals is produced by subjecting disks of metal, placed between hard steel dies, to an intense and sudden pressure, which is so great that the metal disk is not only changed in form, but its *volume* after being struck is appreciably less than before.

For a long time, liquids were regarded as incompressible, and this opinion seemed to be confirmed by many experiments which the Academy of Florence made during the end of the seventeenth century. Their most celebrated experiment, which, however, had previously been made by Lord Bacon, consisted in filling a hollow silver sphere with water, and after stopping the orifice with a screw-plug, subjecting it to the powerful pressure of a screw-press. It is evident that if the sphere is flattened, its capacity is diminished, and the water compressed. They were surprised, however, to see the water appear on the exterior surface, as a fine dew, and they thence concluded that water was incompressible, and silver porous to this liquid.

John Canton, in Trans. R. S. 1762, first showed that liquids were compressible, even with the pressure of one atmosphere. His apparatus consisted of a large thermometer which contained the liquid, and the bulb of which was inclosed in an exhausted receiver. The liquid was thus entirely relieved of atmospheric pressure. The height of the liquid was now marked upon the stem, and the end of the sealed thermometer tube being broken, the air was allowed to enter the stem and press upon the surface of the liquid, and to enter the receiver and press upon the outside of the bulb. The liquid instantly fell in the tube, thus clearly showing a compression produced by the pressure of one atmosphere.

Canton thus found that water was compressed $\frac{46}{1000000}$ths of its volume by the pressure ef one atmosphere, and this determination is quite exact.

In 1826, Jacob Perkins described in the Trans. R. S. an appparatus which renders the compressibility of liquids very evident. Into a hollow cylinder passed a rod through a stuffing-box, and around this rod tightly fitted a leather washer, which rested on the top of the cylinder. This apparatus being filled with water, or other liquid, was placed in a closed cannon, into which water was forced by a strong pump, until a certain pressure was attained, which was measured by the lifting of a safety-valve and the escape of water.

On taking out the cylinder from the cannon, the leather washer was found on the rod several inches above the place it occupied before the experiment, thus showing that the rod had entered by that quantity into the vessel, as the pressure which it exerted compressed the liquid.

Describe and use Œrsted's piezometer, and exhibit table of Regnault and Grassi's results on the compressibility of liquids.

Gases, of all bodies, are the most easily compressed. This fact is readily shown by enclosing a gas in a cylinder, into which glides an air-tight piston. By pressing on the piston, it is forced into the cylinder, and the gas is reduced in volume. On relieving it of pressure, the gas expands to the volume it had before the experiment, and will do so no matter into how small a volume it may have been compressed, or how often the experiment may have been made. In this respect (of perfect elasticity) gases and liquids differ from solids. This is explained by the fact, that the ultimate parts of solids have *polarity*.

It is found that by pressure, gases are reduced to volumes, which are the reciprocals of the pressures.

## 6. *Dilatability.*

When any body is subjected to exterior pressure on all its surfaces, it is forced into a smaller volume, but on the pressure being removed, it expands to the dimension it had before the pressure was applied. Also, the volumes of all bodies are increased by a rise in their temperature: and Cagnard—Latour has shown that wires and rods when stretched, have their volumes increased.

This general property of increase in volume from these causes is called dilatability.

The dilation of solids and of liquids is shown by their expansion, when relieved of hydrostatic and atmospheric pressures; and any gas expands when the atmospheric pressure is removed.

*Experiments.* The expansion of solids shown when relieved of powerful pressure. The experiment of Canton *reversed*, shows the expansion of a liquid as the pressure of the atmosphere is removed.

The expansion by heat, shown by Saxton's pyrometer, of liquids and of gases by large liquid and air thermometers.

Experiments of stretching wires and India-rubber, with Cagnard—Latour's apparatus.

(To be continued.)

## PATENTING A PRINCIPLE.*

THE opinions of professional men are far from being settled, apparently, upon all the questions involved in patenting a principle. Perhaps there are not many who suppose that having discovered such a principle entitles the discoverer to appropriate it under a patent, provided he has reduced it to practice. The current of decisions has been so uniform in recognizing the title as belonging to the one who has first made a useful application of a law of nature, and upon that ground alone, that a person can hardly be found who believes the title to be strengthened in consequence of having brought the law to light. A much greater diversity of sentiment exists as to the extent of the right which the individual acquires in the principle so applied, and the form in which a patent should be expressed in order to protect the right. On the one hand, it seems to be held that he is entitled to the exclusive use of the principle, when employed for the same purpose by whatever instrumentalities the purpose is effected; and that the patent should expressly claim, not only the instrumentalities adopted by the patentee, but also the use of the principle for the purpose however applied. Others believe that, having shown by what means the principle can be made to accomplish the object, the patent, although it covers only those means in express terms, yet confers an exclusive privilege in the employment of the principle to accomplish the object, let the means resorted to be ever so different. On the other hand, it is regarded by many as well settled, that he who has invented a method by which a property of matter can be, for the first time, rendered useful for a particular purpose, is entitled to a patent for the method, or process or mechanism which he has contrived, and that he can set up no claim to anything more, nor vindicate a right to anything more.

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* The above article is from the pen of S. H. Hodges, Esq., senior member of the Board of Appeal, in the United States Patent Office, and was officially "commended to the Examiners of the Patent Office for their perusal and study," by the late Commissioner of Patents. It is well worthy of careful examination as containing a full digest of the law in the interesting question of which it treats.—ED.

Several things have contributed to this discordance of sentiment. One of the most prominent is a misapprehension of the effect and bearing of some of the cases on the subject. It is not necessary to engage in an exhaustive discussion of all the reported decisions in which the question is involved; but some examination of a few of the leading ones seems to be requisite in order to render it clear.

From the earliest date, the established doctrine of the English courts has been that a principle cannot be patented. It has been pronounced from the bench times without number, has been uniformly assumed as the law, and has never once been questioned since Hornblower *v.* Boulton was determined. It appears to have been made the subject of consideration for the first time in two suits brought upon Watt's patent for his steam-engine. In one of them, Boulton & Watt *v.* Bull, 2 H. B. 463, and Dav. Pat. Cas. 162, the court were divided in their construction of the patent, and consequently no judgment was ever rendered. All were agreed in condemning the idea that a principle could be patented, and two of the judges interpreted the grant as embracing a monopoly of a principle, and held it to be void on that ground. The other two understood it to cover only the structure of the engine, and therefore maintained its validity. Lord Chief Justice EYRE uttered the following noticeable sentiments on the occasion: "Undoubtedly there can be no patent for a mere principle. But for a principle so far embodied and connected with corporal substances, as to be in a condition to act, and to produce effects in any art, trade, mystery, or manual occupation, I think there may be a patent. Now this is, in my judgment, the thing for which the patent was granted; and this is what the specification describes, though it miscalls it a principle. It is not that the patentee conceived an abstract notion that the consumption of steam in fire-engines may be lessened, but he has discovered a practical method of doing it; and for that practical method of doing it he has taken out a patent. Surely this is a very different thing from taking out a patent for a principle." The expression "a principle embodied and connected with corporal substances," &c., may have had some part in originating the idea that the principle itself is what may be patented. It may be doubted whether the distinction between a principle embodied in a material structure, and a machine embodying a principle, was in his lordship's mind at all. If it was, the latter part of the quotation shows that it was the machine he contemplated: he says it was "for that practical method of doing it he has taken out his patent."

Having failed to establish their title in that suit, the plaintiffs brought another, which was subsequently carried by writ of error to the Court of King's Bench, and is reported by the name of Hornblower *v.* Boulton, 8 T. R. 99. Judgment was given in their favor upon the sole ground that the patent was for a machine, and not for a principle, as may be seen from the following language of Lord KENYON, Chief Justice: "By comparing the patent and the manufacture together, it evidently appears that the patentee claims a monopoly for an engine, or a machine composed of material parts, which are to produce the effect described." "But having heard everything that can be said on the subject, I have no doubt in saying that this is a patent for a manufacture, which I understand to be something made by the hand of man." LAWRENCE, J., rested the same conclusion upon the language of the Act of Parliament, under which the patent had been extended; saying, "From this it is clear that the legislature understood that the patent was for an engine for some mechanical contrivance." The other judges concurred in these views, and, notwithstanding the strenuous efforts of the counsel to sustain the patent upon the ground that a principle could be patented, they emphatically condemned the position.

Passing over several cases, which will be adverted to in the following pages, the case of Neilson *v.* Harford, 1 W. P. C. 273, and 8 M. & W. 806, next demands attention. The action was brought upon the patent for using the hot-blast in smelting iron, and the like, and was considered at great length in the Court of Exchequer Chamber. The court were chiefly occupied with the objection, that the patent represented the form of the vessel in which the air is heated to be immaterial, and this the jury had found was not true, certainly in one sense. It was also urged that the patent was for a principle; and respecting this, Baron PARKE, who pronounced the opinion, made these observations: "Then taking the construction of this specification upon ourselves, as we are bound to do, it becomes necessary to examine what the nature of the invention is which the plaintiff has disclosed by this instrument. *It is very difficult to distinguish it from a patent for a principle, and this at first created in the minds of some of the court much difficulty;* but after full consideration, we think the plaintiff does not merely claim a principle, but a machine embodying a principle, and a very valuable one. *We think the case must be considered as if, the principle being well known, the plaintiff had first invented a mode of applying it* by a mechanical apparatus to a furnace. And his invention then consists in this, by interposing a receptacle for heated air between the blowing apparatus and the furnace" (W. P. C. 370, 371). It is difficult to see how they could have more emphatically denied that a principle can be patented. The inventor had brought to light a property of matter of immense value, and had rendered it practicable. If there was ever a case in which such a discovery should be protected it was this, and the court were evidently actuated by an earnest desire to secure to the discoverer his reward. Yet they found themselves compelled to put a forced interpretation upon his grant, and to construe it as covering the structure he employed, because they could not, with due regard to their legal convictions, allow him to monopolize the property of matter. They add this pregnant remark: "We think the case must be considered as if, the principle being well known, the plaintiff had first invented a mode of applying it." They give him no credit for having been the first to eliminate it, and make it known. They estimate his merit by the application which he had made of it, and by that alone.

The same patent came under consideration soon after in The Househill Co. *v.* Neilson, W. P. C. 673, a case which requires a more careful examination, perhaps, than any other on the subject, both on account of the erroneous significance which has been attached to it, and the influence it has exerted in misleading many of the profession. It was tried first by the Court of Sessions in Scotland, Lord Justice Clerk HOPE presiding, and then on appeal by the House of Lords. The defendants undertook to raise questions which involved the objection that the patent was for an abstract principle, and therefore void. Lord HOPE thereupon (p. 677) expressed his conviction that they were not at liberty under the pleadings, or issues as settled, to go into that defence. On inspecting the issues (p. 674), it will be clearly seen that no such point was raised. Nevertheless, in order to enable the defendants to carry up the question, he concluded to entertain the objection, and treat it as if it were legitimately before him. Accordingly, he proceeded to instruct the jury in unqualified terms, that the plaintiff, having discovered the principle, and shown how it might be applied usefully, was entitled to a patent for the principle. All this, however, was on the erroneous hypothesis that the objection had been properly taken.

It has been said, however, that this ruling of Lord HOPE'S was affirmed upon the hearing of the appeal before the House of Lords. It is true that all the exceptions taken by the defendants to his lordship's instructions were overruled on that occasion, saving one, which has no bearing on the question under consideration. The reason is to be learned from a foot note to the report, on p. 711. From that it appears that, when the counsel for the appellants (the defendants below), approached this part of the case, the law lords expressed such a decided conviction that the objection to the patent on account of its being for a principle, could not be raised under the pleadings and issues, that the objection was abandoned. And in accordance with this we find Lord CAMPBELL interposing in the course of the argument, and asking the counsel for the appellants "what issue have you on this record to raise the question of the patent being for a principle?" And after some further conversation he told them "You might have pleaded that it was a patent for a principle, and not for any particular mode of applying a principle. There is no issue for the direction of the judge upon that point:" pp. 701, 702. And Lord LYNDHURST mentioned, in delivering his opinion, that he understood the counsel to abandon that defence (p. 711). The decision below was affirmed, nevertheless, because, since the defendants could not raise the question at all, they were not injured by an adverse ruling respecting it, and could not allege it as an error, so as to set aside the judgment. The whole authority of the case, therefore, rests upon the instructions given by Lord HOPE to the jury, hypothetically and upon a supposition that had no foundation, as he himself believed.

Among the American cases on this subject two are prominent: those of Le Roy *v.* Tatham, 14 How. 156; and O'Reilly *v.* Morse, 15 How. 62.

In the first of these the patentees described in their specification a property of lead, which had been discovered by them, viz: that, if divided when just congealed, and then pressed together while still hot, the edges will unite. This they had reduced to practice in a machine for making lead pipe, and it was found to be a valuable improvement. Judge McLean, who gave the opinion of the majority of the court, interpreted the patent as embracing the machine only, and as they determined that to have been anticipated, they condemned the patent.

(To be continued.)

# FLAME REACTIONS.

By Prof. Bunsen.

Translated by Prof. Charles F. Himes, Ph. D., Dickinson College, Carlisle, Pa.

(Continued from page 269.)

## XXIV.—Behavior of Molybdenum Compounds.

A. *On a charcoal rod with soda*, molybdenum is reducible to a gray powder, but with such difficulty, that its detection in this way is unadvisable. Some molybdenum compounds likewise give, in the upper reducing flame, with great difficulty and incompletely, a metallic incrustation upon porcelain, and at the same time color the flame greenish. Molybdenum is recognized best in its compounds in the following way:

B. The test-specimen, finely pulverized by means of the steel blade, Fig. 4, A, upon the porcelain plate, Fig. 3, is mixed upon the hand with soda, which is obtained in the pasty condition best adapted to mixing, by fusing off a portion of a crystal of carbonate of soda. After the mixture has been fused for a few seconds in the lamp-flame, in a spiral of platinum wire of the thickness of a hair, from two to three millimetres wide, the white-hot fluid contents of the spiral are knocked off on to the lamp-plate, then digested with two to three drops of water by warming, and the clear liquid above the sediment is soaked up into three or four strips of filter-paper, not too fine, several millimetres broad.

B′. One of these strips when moistened with hydrochloric acid does not change its color, but if a drop of ferrocyanide of potassium is placed upon the moistened paper, it becomes reddish-brown.

B''. If one of the strips is gradually moistened with a few milligrammes of proto-chloride of tin, it either becomes blue, even in the cold, or upon gently warming it; if it becomes yellow or yellowish-brown, more of the solution of the test-specimen, treated with carbonate of soda, must be added by means of a capillary pipette, in order to cause the blue color to appear.

B'''. A drop of sulphide of ammonium placed upon the third strip produces a brown coloration, and upon the addition of hydrochloric acid a brown precipitate, whereupon the paper often becomes blue on the margin of the precipitate.

B''''. The yellow phosphoric acid precipitate, which the solution in nitric acid of ammonia salts of molybdic acid gives, can be produced in a similar way.

C. The slightly characteristic borax bead is colorless in the oxidizing flame, when it contains more molybdenum bluish, enamel-like; in the reducing flame dark, by reason of separated binoxide of molybdenum.

## XXV.—BEHAVIOR OF TUNGSTEN COMPOUNDS.

The reduction of tungsten on a charcoal rod, with soda, also succeeds, but is also not adapted to the separation or recognition of the metal. The compounds of tungsten are therefore treated in the manner just given for molybdenum, by soaking up the fluid, after fluxing with soda, on to strips of blotting paper.

A. One strip moistened with hydrochloric acid remains white, but becomes yellow upon heating; moistened with ferrocyanide of potassium, no coloration occurs.

A''. Another strip treated with drops of proto-chloride of tin becomes blue, even when cold, or upon warming.

A'''. A drop of sulphide of ammonium produces no precipitate upon a strip, neither alone nor after the addition of hydrochloric acid; the paper, however, is colored thereby blue or greenish, especially upon warming.

## XXVI.—BEHAVIOR OF TITANIUM COMPOUNDS.

These give, with microcosmic salt, in the oxidizing flame, a colorless bead, which acquires a slight amethyst color in the reducing flame. After the addition of some sulphate of iron, the bead acquires in the lower reducing flame the peculiar red color of venous blood, in the oxidizing flame the bright brown color of sesquioxide of iron can be reproduced as often as desired. The titanium compounds are fluxed with carbonate of soda, with effervescence, to a bead, transparent during ignition, opaque upon cooling, which, when treated with proto-chloride of tin, whilst still hot, and exposed in the lower reducing flame, forms a gray mass, which dissolves in hydrochloric acid with weak amethyst color upon warming it upon the lamp-plate.

### XXVII—XXVIII.—BEHAVIOR OF TANTALUM AND NIOBIUM COMPOUNDS.

These manifest the same reactions as those of titanium.

### XXIX.—BEHAVIOR OF SILICA COMPOUNDS.

A. The silicates, when treated in the oxidizing flame with carbonate of soda, dissolve, more or less, with effervescence. The hot fused mass, when moistened with proto-chloride of tin and thoroughly ignited, does not give a trace of a blue coloration when evaporated upon the lamp-plate, whereby silica may be distinguished from titanic, tantalic, and niobic acids. It likewise fails to give the blood-red coloration in a bead with sesquioxide of iron, produced by these acids. The fluxed mass, if water and acetic acid are carefully added, and then evaporated on the lamp-plate, separates gelatinous hydrate of silica. Fine splinters of silicates give, upon fusing in the bead of microcosmic salt, a gelatinous skeleton of silica, floating in the fused or cooled bead.

### XXX.—BEHAVIOR OF CHROMIUM COMPOUNDS.

A, *In the platinum spiral with carbonate of soda*, the compounds of chromium when fluxed with the repeated addition of nitrate of potash, give a bright yellow mass, which, when knocked off on to the lamp-plate, and crushed, gives a bright yellow solution. If this solution is separated from the residue, by carefully allowing it to run off, and acidified with acetic acid, it becomes yellowish-red, and gives with lead salts, when it is soaked up into strips of paper, a yellow precipitate, with solution of salts of oxide of mercury a red one, and with solution of silver salts a reddish-brown one.

With sulphide of ammonium, as well as by evaporating with aqua regia upon the lamp-plate, the solution becomes green; likewise with proto-chloride of tin.

B. *The borax bead* becomes emerald-green in the oxidizing flame, and does not change this color in the reducing flame.

## XXXI.—BEHAVIOR OF VANADIUM COMPOUNDS.

A. Upon treatment of compounds of vanadium with carbonate of soda and nitrate of potash in a platinum spiral, a bright yellow fluxed mass is obtained, the solution of which, acidified with acetic acid, is precipitated yellow by nitrate of silver. The fluxed mass when heated with aqua regia does not give a green solution, but a yellow or yellowish-brown one, which only becomes blue after the addition of proto-chloride of tin. If the fluxed mass contains much vanadic acid, its solution, when much concentrated cold hydrochloric acid is added to it, gives a yellowish-brown color or precipitate.

B. *In the borax bead*, compounds of vanadium produce in the oxidizing flame a greenish-yellow color, in the reducing flame a green color.

## XXXII.—BEHAVIOR OF MANGANESE COMPOUNDS.

A *Borax bead*, amethyst in the oxidizing flame, colorless in the reducing flame.

B. *With carbonate of soda on platinum wire*, a bead is formed green after cooling, especially easily after addition of nitrate of potash. Water extracts a green solution from it, which becomes red after the addition of acetic acid, and then, often with the separation of brown flakes, becomes colorless.

## XXXIII.—BEHAVIOR OF URANIUM COMPOUNDS.

A. Give a yellow bead in the oxidizing flame, which becomes green in the reducing flame, especially easily after moistening with proto-chloride of tin. The colors are very like those of the compounds of iron; they can, however, easily be distinguished, if no other oxide which might impart a color is present, by the fact that the uranium bead emits a bluish-green light during ignition, similar to that which the uranium compounds manifest in fluoresence. Borax beads of oxides of lead, stannic acid, and several other substances manifest upon ignition a similar appearance, but are not of the same color after cooling as the uranium bead.

B. The insoluble compounds of uranium are fluxed by treatment with bisulphate of potassa, near red heat in the fine platinum spiral. The fluxed mass is triturated with a few grains of crystallized carbonate of soda, and the liquid portion of the triturated and somewhat moistened mass is soaked up into blotting paper. With ferrocyanide of potassium a brown spot is produced upon the paper moistened with acetic acid.

## XXXIV.—BEHAVIOR OF COMPOUNDS CONTAINING PHOSPHORUS.

These can easily be detected in the following manner, even if mixed with a large amount of other substances:—The test-specimen, after ignition, is crushed fine upon the lamp-plate, and placed in a glass tube, drawn out to the thickness of a straw, and fused shut at one end, and a piece of magnesium wire, two lines long, is added, which must be covered by the test-specimen. When the tube is heated phosphide of magnesium is formed, whilst the contents glow intensely. The black contents of the tube, after it has been crushed upon the lamp-plate, give when breathed upon, or moistened with water, the very characteristic odor of phosphuretted hydrogen. In the absence of magnesium wire, a small piece of sodium will answer as well.

B. If it has been ascertained that the test-specimen does not give an incrustation upon porcelain in the upper oxidizing flame, the phosphates can also be recognized by the fact, that they give a polished fused globule of phosphuret of iron upon platinum wire, with boracic acid, and a piece of iron wire, of the fineness of a hair, in the hottest lower reducing flame, which can be drawn out of the boracic bead, crushed under paper, by means of the magnetic knife-blade.

## XXXV.—BEHAVIOR OF SULPHUR COMPOUNDS.

A. *On a charcoal rod with carbonate of soda*, in the lower reducing flame, they give a fused mass, which moistened upon a piece of silver blackens it. Since selenium and tellurium produce the same reaction, the absence of these substances must be determined by the absence of a tellurium or selenium spot upon porcelain.

B. Where only metallic sulphides are to be considered, and not sulphates, it will answer simply to heat the test-specimen in the flame in order to recognize sulphur by the odor.

(To be continued.)

# EDUCATIONAL

## THE MAGIC LANTERN AS A MEANS OF DEMONSTRATION.

(Continued from page 278.)

### THE MEGASCOPE.

In any course of lectures on optics, the manner in which an image is formed by a lens, must, of course, be discussed, and it becomes very desirable that some demonstration should be given of the fact that not only do luminous objects, such as the flame of a candle, emit rays, which, when sorted, as it were, and focalized by the lens, produce images on a screen, but that other bodies, also, which are only illuminated by light, foreign to themselves, reflect it in such a manner as to bring them in this relation to lenses, in the same condition as self-luminous objects.

In addition to this, notwithstanding all the drawbacks (and we shall see that there are many,) which attend the adjustment of this experiment, yet within its proper limits, and with such judicious selection of objects as we shall presently describe, the projection of images from non-luminous objects is one of the most surprising and agreeable of experimental demonstrations.

It therefore becomes very desirable to adjust the lantern for use in this manner, and, after some experiment, I have succeeded in accomplishing this with very little change in the arrangement, or addition to the parts of the lantern already described.

We need, in fact, nothing additional to the lantern formerly noticed, Vol. 54, p. 132, but a simple lens mounted in a cell, and having a diameter of about four inches, and focal length of twelve inches.

In this case (referring to the cut, 10, on the page just cited,) we remove the condensers and objectives, and substitute for the latter the lens above-mentioned, connecting it with the hole left by the condenser in the lantern, by a short tube sliding into the said hole, and with a cloth thrown around it, to stop up any cracks which may be left.

Within the lantern, we then turn the jet and lime entirely round, so that it throws its light towards the back door, and move it as far to one side as possible. If a large prism of lime is used, no further precaution is needed; but if a small piece which becomes heated luminously on both sides, is employed, a little shield of tin, or the like, must be attached to prevent its light from passing directly to the lens. The inside of the back door is finally covered with a piece of white paper.

Matters being thus arranged, introduce one hand through the curtained opening in the side door, and with the other adjust the lens front and back for the focus.

An image of the hand, of gigantic size, will then appear on the screen, which, if other things are in good order—*i. e.*, the lime-light bright and the room dark—will, on the first trial, astonish the operator as much as any one else. The combination of color and motion, with strong effect of light and shade, will produce an appearance of relief or solid extension, compared with which the best displays of the dissolving lantern are insignificant. I can yet remember my own impressions on first trying this, and that with my own hand in the lantern, and giving to my own fingers the motions I saw repeated on the screen, it required an effort to realize that the image seen was something depicted on a flat surface, and not a huge solid body projecting into the room, and capable of seizing anything which approached.

This effect can be admirably produced in a room about forty feet square, on a good screen of twelve feet in diameter, and with the lantern about twenty-five feet from the screen. What is required for larger rooms, we will state presently.

Besides the hand, which is one of the most striking objects which can be employed, we have in order of merit, the works of a watch, so held as to reflect the light fully; a wine-glass full of wine, or wine-colored liquid; a strongly-marked miniature or photograph in an embossed metal frame; a small, metal coal-oil lamp with chimney, burning; a rosy-cheeked apple, &c.; plaster medallions with strong relief; a colored picture, which, however, shows poorly, because coming in contact with the more brilliant magic lantern display of the same objects.

An apparatus of some sort to display opaque objects, as above, has been repeatedly devised and exhibited, and has gone out of use again, chiefly because too much was claimed for it, and the disappointment of unreasonable expectations gave it discredit.

For reasons which were fully discussed in one of these papers (see Vol. LIV., p. 340), it must, of necessity, even with the most costly lenses, be vastly inferior to the magic lantern in sharpness of definition and flatness of field, while in amount of illumination it is enormously behind.

If, then, we expect to substitute it in any way for the other instrument, we shall certainly be disappointed; but, if at a little cost, we can add it to the other, and use it only for those few experiments for which it is fit, and which cannot be in any other way produced, it will be found of much interest and service.

Sir David Brewster, in his "Natural Magic," p. 86, was, we believe, one of the first to suggest such an arrangement, which, however, as there indicated, is quite impracticable. In another paper on the magic lantern, he even proposed to arrange a solar or gas microscope, in like manner, for solid objects, which shows us how far one may go astray by allowing invention to run unchecked by fact or reflection. Dr. Pepper, in his very suggestive "Play Book of Science," p. 286, describes a plan which would be admirable, if one only had a first-rate parabolic mirror; and, on page 308, another, to which we presume the artist and engraver have not done justice, for certainly no such instrument as is represented would ever produce the results stated.

If the apparatus is constructed in any manner as described, it must be very costly and feeble in illumination.

Those who have arranged these instruments, have generally concerned themselves much with arrangements for concentrating light on the object by means of mirrors, &c.

This we believe to be quite unnecessary, for a lime-light brought as near to the object as possible, without burning it, will illuminate it fully as well as if the same light is set further off and has its rays concentrated by any optical means.

The objection to two lights is, that they destroy effect of relief, and are only of use with pictures, which are exactly the sort of objects least available for this instrument.

When I use this apparatus in a larger room than that described before (say one fifty by eighty feet), and where, therefore, more light is required, I employ a lens of six inches diameter and twenty-inch focus, with a double jet (the two jets within a half inch of each other,) and a larger lantern-box.

(Continued from page 288.)

# ON THE FUTURE DEVELOPMENT OF SCIENTIFIC EDUCATION IN AMERICA.

By S. Edward Warren, C. E.

*Prof. of Descriptive Geometry, &c., in the Rensselaer Pol. Inst., Troy, N. Y.*

Above all, the error contemplated is to be removed by dispelling the mists that obscure the distinction between *collegiate* (scientific) and *professional* (scientific) or *polytechnic* education, as to their *range*, and *aims*, and *governing ideas.*

But this can probably never be accomplished by words alone. The truth must infiltrate itself into the popular mind by means of familiarity with practical examples of High Schools, Colleges and Professional Schools, each in due degree and proportion, and mutual adaptation, devoting itself principally to mathematical, physical and graphical science.

As the case now stands, the middle member of the three successive institutions just named, is practically found in the "scientific courses" parallel with the "classical" ones, in some colleges, also in the earlier stages of the polytechnic schools. But it has no separate formal existence yet; and, as the two substitutes for it, just described, partly cover the same ground, there is a lack of system and order yet to be supplied. Therefore, as before explained, since the existing polytechnic (professional) schools best know what preparatory courses of general or collegiate disciplinary cultures they require, let them create the collegiate order of institutions to which such courses belong, by a process of development and division out of their own substance.

We are now free to say, that the next great step by the professional schools of science, after the establishment of a four year's course of study, is the *extension* of that course by at least one year, with at least no depression of the conditions for admission: and then the division of that total course into two formally distinct and well-defined successive classes, viz:

A general disciplinary or collegiate course, composed of general science, and modern literature and philosophy, and

A technical, that is, a professional course in the theory and illustrated practice of each of the professions at least, whose basis is in the exact sciences, viz: Architecture and Engineering, the latter in its well-defined branches of road and bridge engineering, hydraulic engineering, mechanical engineering, mining engineering. Civil Engineering proper, relating to works for the *general* benefit and use.

Having thus again reached and confirmed the same conclusion as before, we shall next endeavor to explain, in detail, the scope and composition of the two successive courses above defined.

In the *general* course, the *primary* and *immediate* object would be the development *of mental power*, or in the well-worn phrase, the "discipline of the mind."

In the technical courses, the immediate object would be training for the practice of any of those high industrious callings requiring an extensive and exact knowledge of principles, together with expertness in the elements of various departments of practice,—chemical, geodetical, graphical, &c.

But before going further, truth to the facts of life requires an important explanation. Observe that we say, "the *primary* and *immediate*" object of the general course is development of mental power in the student, irrespective of any practical pursuit to which he may apply that power. We speak thus, because of the cardinal truth that things *logically* separable are *vitally* united. In other words, things distinct or distinguishable in *thought*, are intimately united in *real life*.

To illustrate, by reference to physical culture. A young man going through a course of general gymnastics would be said to be *immediately* seeking a sound general muscular development—in symmetry, power and flexibility, with certainty of accurate concerted action between eye and limbs.

Nevertheless, if the youth contemplated a subsequent career as an expert skater, swimmer, oarsman or horseman, he could not but enter upon his general gymnastic practice, with more zeal and vigor if he regarded not only its *immediate* end as above described, but also its *ultimate* end as a foundation for the subsequent proposed branch of special skill.

Now the point is this. Earnest spirits cannot but be chiefly enlisted in the contemplation and pursuit of *ultimate* ends; of final and practical or "concrete" results.

Hence, though the *immediate* and *logical* end of merely general, commonly known as the collegiate grade of education, truly is the *conscious* development of actual mental working power in the student out of his previously undeveloped capacities; yet who goes to college with this object steadily uppermost in his thoughts? Rather who does not go because *after graduating* (there is where his living thoughts, purposes and beckoning visions centre), he means to enter a professional course under the best conditions, in order to be a lawyer, physician, teacher, clergyman, or professionally a man of letters; and because he knows that he can better obtain these positions by bringing trained faculties to bear on the acquisition of them.

We have, then, these two principles:

I. Things separate or separable in thought, are vitally united in practical life.

II. *Ultimate* ends are both contemplated and pursued, with the steadiest and liveliest interest.

To which we add a third:

III. Classification of complex objects, as courses of study, is *not* based on the *exclusive* presence of some determining feature, but on its *predominance.* Thus, a classical education is not one which consists *only* of the study of the Greek and Latin languages and literature, but *principally* of these things.

So, then, to be true to mental life, we would say that both in *general* and in *professional* education, some future sphere of high activity is the *practical* end, cherished with most pleasure and with most *effect* upon daily progress. Only, fitness for such activity is the *immediate* end of *professional* education, and the *remote* end, only, of general *collegiate* or "disciplinary" education.

But mental discipline itself is likewise an end of both grades of education. Only it is the *primary* (*logical*) end of general or collegiate education, and the *incidental* (though truly a real) end of professional education.

To complete this branch of our discussion, we will re-define, with an effort at improvement, four marked successive grades of education mentioned in the "Notes of Pol. Schools" by the present writer. The whole of systematic education exists in two graded divisions:

I. Study *passively pursued*, that is, all which *precedes* the age of conscious self-culture and development; and consequent intelligent preference of one line of future study to another; and choice, or at least, interested deliberation upon future life-pursuits.

II. Study *actively pursued*, embracing all which succeeds the recognized attainment of the age just mentioned.

In the former case, the child acts from instincts of obedience to an external guiding power, viz., parental authority.

In the latter stage, the student, properly so-called, obeys an impelling law within himself, and is self-destinated; though the means for attaining his self-determined destination are, because of his inexperience, selected by those who have already entered upon their self-chosen career of practical life.

The relation of these grand divisions to each other, is this: the object of the former is, to develope the mind up to the point of choosing its subsequent line of study for itself, agreeably to its self-chosen future career. Further, each of them exists in two parts. The *first* embraces:

1. *Rudimentary education*, which is that without which there can be no knowledge, so far, of course we mean, as knowledge results from school instruction. Thus, without knowing how to count and add and subtract, there can be no knowledge of numbers, or reckoning, or of relations of quantity.

2. *Elementary education*, which extends to operations involving the use of one or more of the rudiments; as in arithmetic again, operations on vulgar fractions, square-root, least common multiple, &c., involve the single or combined use of "ground rules."

The *second* grand division embraces—as already stated—

1. *General education*, whose *immediate* and *logical* end is, development of mental power; but whose *remote* and *practical*, and withal *chiefly operative* end, is practical success in life.

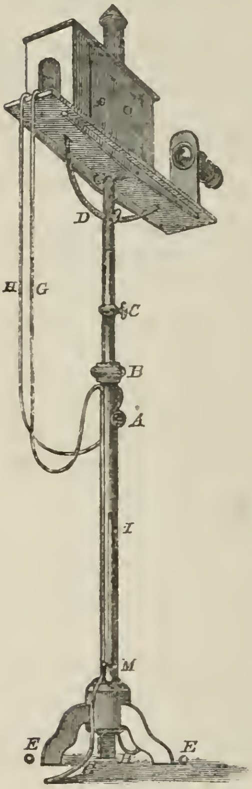
2. *Professional education*, whose *immediate* end, both logical and practical, is actual fitness for a chosen practical sphere of action: and whose *incidental* and *real*—even if unthought of—end, is further mental discipline.

To finally complete this discussion, nothing now seems wanting but to broach a curriculum for each grand division of an institution, embracing its own collegiate training within the sphere of its own organization.

This, at a future time, we will attempt to do, coupled with comments on the unrecognized purely disciplinary power residing in certain branches of study.

R. P. I., March, 1868

## NEW STAND FOR A LANTERN.



In order to render possible a wider range of lecture experiments on the subject of Light, with the ordinary magic lantern, the following construction for a stand has been resorted to. The base of the stand is a small wooden tripod, with a heavy oaken central block. The spread of the limbs of the tripod is so small, only fifteen inches, that they are entirely out of the way, and at the same time, by means of thumb-screws, which are passed through iron plates, E E, the stand is made firm. Securely fixed into the tripod is an iron tube, an inch and a half in diameter, which rises to the height of forty inches from the floor, and is capped with a wooden annulus, B. An iron rod slides up and down in the tube, carrying with it the table tops, two in number, the smaller one fifteen inches by twenty-three, the larger, twenty by thirty-seven inches. The former is permanently fastened, the latter is attached, when needed, by screws. The sliding rod is prevented from leaving the tube by a ring at its lower end, which strikes against the annulus, B. It is fixed at any height by a screw with a ringhead, A. C is a brass ring with a clamping-screw, which can be secured anywheres along the sliding rod. When the screw A is loosened and C fixed, the table falls until C strikes upon B; it may then be revolved through any angle, and again secured by A. On the lower side of the smaller table-top are two wooden strips, provided with holes for the ends of a cross-bar, which is fastened to the top of the sliding rod, and upon which the table turns. It is fixed at the required elevation by the screw P, which passes through the sliding rod, and presses against a semi-circular iron hoop, with a radius of six inches. G and H are the tubes for conveying the Oxygen and Hydrogen gas. The part I attached to the stand, is copper, one-quarter of an inch in diameter. It is attached by a short connecting tube, one-sixteenth of an inch diameter, with a tube three-quarters of an inch across, and two inches deep, closed at both ends, so as to serve for the reservoir of a water-guage, M. Another tube, of copper, soldered into this, and passing down to the bottom of the copper bottle, is connected, by a short india-rubber tube, with a glass tube, for indicating the pressures. Only one of the tubes and gauges is seen in the drawing, the other being upon the opposite side of the stand.

The lantern box is fastened to the table-top in such a way as to be disengaged in a very few moments. Four plates of iron are secured fast to the bottom of the lantern, and four more are let in flush with the table. Through the former, iron keys are passed, which fit into openings in the latter, and a quarter revolution of the keys fixes the lantern securely.

*Demonstration of the Refraction of Light.*—It has been customary, in the demonstration of the refraction of light to a large class of students, to place the lantern with the lime or electric light, in a horizontal position, and alter the direction of the ray until it struck upon the surface of the refracting body at the desired angle. This change of direction was effected either by a square prism or a plain mirror. The foregoing arrangement of the table, permits the direct ray to be sent in any path with equal facility. The tank for performing the experiment is best constructed of two semi-circles of plate-glass of one foot radius, separated by an india-rubber strip, such as photographers use for their large baths, at an interval of one inch and a half, and clamped together in a brass cell. On the forward side of the latter, the graduation may be made. The cost of this elegant piece of apparatus is not great. A diaphragm placed in the lantern with three holes, a quarter of an inch in diameter, and placed in a vertical line, will allow three slightly divergent beams of light to pass through it—their change, of course, at the surface of the water in the tank, is very noticeable.

*Examination of Precipitates.*—The top of the table is turned into a vertical position, so that the nose of the lantern points to the zenith. A square prism fastened by side tabs to a brass or tin ring, which fits tightly into the draw-tube of the objective, turns the ray of light through a right angle, and causes it to fall upon a screen placed in the usual position. There is not that difficulty about the management of the light, which might at first thought be expected. The board which carries the cylinder, is prevented from falling out at the rear, by a little slip of brass fastened by a screw at one end, and slipped around upon the board when necessary. Care, however, must be taken, that the lenses forming the condenser, be not too cold at the time of commencing the experiments. Otherwise, the moisture which is so abundantly formed by the union of the gases, will be precipitated in such quantities as to cause serious inconvenience. A sudden change of temperature, moreover, may fracture the lens. The vessel in which it is intended to perform the reactions, is placed upon the condenser of the lantern. The depth of liquid should not exceed one inch. Chemical changes thus seen in plan instead of elevation, so to speak, assume a very novel appearance. The fluid, before perfectly colorless, perhaps, is thrown into undulations by the sudden entrance of a drop of the reagent, and then from the latter as a centre, wreaths of the colored precipitate make their appearance. An ordinary glass vessel does not answer very well for these experiments. The bottom of such is always more or less lenticular, and while it may render the picture on the screen more curious-looking, it does not contribute to a proper understanding of the reaction. A dish which entirely obviates this difficulty, may easily be constructed in the following manner. A disc of plate-glass five and a half inches in diameter, or three-quarters of an inch more than the diameter of the condenser, is easily cemented into a ring of tin or brass, and forms the bottom of a shallow vessel. Although scarcely necessary, a coating of paraffine protects the metal.

*Cohesion Figures.*—While a vertical tank may serve for the exhibition of precipitates, it will not do at all for Cohesion Figures, which are formed only at the surface, and which to be seen properly, must be viewed from a position vertically above or below the liquid. The arrangement just described, puts a large audience in the position of a single observer. Seen upon a screen, and greatly magnified, these figures have a most peculiar appearance. They are formed when a drop of sulphuric ether, alcohol, naphtha, the oils of almond, clove, lavender, colza, sperm, olive, or of creosote, carbolic acid, &c., falls upon the surface of water. For a full account of them, see the *Philosophical Magazine*, October, 1861. The vessel should be chemically clean, and the water pure. The Cohesion Figure formed by ether or alcohol, is of too short duration to be satisfactory for a screen experiment—that of creosote and others, is better.

# Franklin Institute.

### Proceedings of the Stated Monthly Meeting, March 18th, 1868

THE meeting was called to order, with the Vice-President, Mr. Coleman Sellers, in the Chair.

The minutes of the last meeting were read and approved.

The Actuary submitted the minutes of the Board of Managers and reported that, at their stated meeting, held March 11th, inst., a letter was received from Lieut. Col. D. E. Macpherson, of Allery, Melrose, Scotland, announcing the death of his father, Sir David Brewster, on the 10th of February, ult., in the 87th year of his age, which was referred to the Institute to take suitable action.

Donations were received from the Royal Astronomical Society, the Statistical Society, the Society of Arts, the Royal Geographical Society, the Institution of Civil Engineers, London, and the Association for the Prevention of Steam Boiler Explosions, Manchester, England; l'Academie des Sciences, and la Societé d'Encouragement pour l'Industrie Nationale, Paris, France; J. Smith Homans, Esq., New York; Hon. G. M. Dodge, Chief Engineer Union Pacific Railroad, Omaha, Nebraska; Dr. John F. Boynton, Syracuse, New York; Dr. J. Graham Tull, and Dr. Thomas S. Kirkbride, Philadelphia.

The various Standing Committees reported their minutes. A paper on Telescopic Measurements was read by Mr. B. S. Lyman, Mining Engineer.

The Secretary's report on Novelties, &c., was then read.

A committee consisting of Prof. R. E. Rogers, M.D., and Prof. H. Morton, was appointed by the President to prepare resolutions on the death of Sir David Brewster.

After which the meeting adjourned.

HENRY MORTON, Secretary.

# Bibliographical Notices.

*A Treatise on Meteorology.* By Charles Loomis, LL.D., Professor of Natural Philosophy and Astronomy in Yale College. Harper & Brothers, New York. J. B. Lippincott & Co., Philadelphia.

The above work, gotten up in a plain, substantial style, is intended chiefly as a text-book for students. It is illustrated by a large number of wook-cuts, and three steel engravings. It is printed in short, concise sentences or divisions, faced with bold type which at once catches the eye, and gives the work an interesting appearance. The first three chapters are devoted chiefly to the temperature and tension of the atmosphere, and the instruments for measuring it.

Chapter fourth is devoted to the motions of the atmosphere; the trade-winds: causes of the winds; hot winds of the desert, &c.

Chapter fifth is an exceedingly interesting one, upon the precipitation of vapor contained in the atmosphere. Under this head are included the formation of dew; formation of hoar frost, fogs, clouds, rain, snow and hail.

Chapter sixth relates to storms, tornadoes and water-spouts: the cause of storms, &c; cyclones; paths of cyclones and tornadoes; disastrous effects of tornadoes and whirlwinds, water-spouts and pillars of sand; showers of toads, fish, oranges, &c.

The next chapter is devoted to predictions of the weather, from various causes, as from the clouds, dew, hales, coronæ, &c.

Several chapters are next devoted to electrical phenomena, atmospherical electricity, electrified clouds; lightning in its various forms, as fork or zigzag, ball lightning, sheet lightning.

Causes of thunder; the aurora borealis; theory of the polar light; twilight; twinkling of the stars; shooting stars; meteors and aerolites.

After this is a series of most valuable tables—thirty-six in number—comprising the relative humidity of the atmosphere, the conversion of French into English measures, &c.

At the end of all is a list of works on meteorology, such as advanced students require. When we first opened this book, we were disposed to expect something exceedingly dry and void of interest to all but the professional meteorologist: masses of tables embodying observations and their elaborate discussion. Our intention was to glance over it, and report the result of this general inspection. In place of which, however, we have read it through with lively interest, and have derived much information from the perusal. It has quite revolutionized our ideas of the science called meteorology, and has revealed the fact that in place of the mere tabulated record which, in the mind of most, represents the subject, it includes some of the most interesting and beautiful phenomena in the range of natural science.

*An Introduction to Chemical Philosophy according to the Modern Theories.* By Dr. Adolphe C. Wurtz, F. R. S., translated from the French, by permission of the author, by Wm. Crooks, F. R. S. London: J. H. Dutton, "Chemical News" Office. 1867.

The present volume presents a concise and systematic view of the birth and growth of chemistry as an exact science. It begins with the history of the terms Equivalent, Atom and Molecule. The idea of equivalency originated in some crude experiments made by Homberg, in 1699, to determine the quantities of different acids which would be required to saturate the same weight of base. It was established on its present firm basis, so far as acids and bases are concerned, by the more accurate researches of Wenzel, in 1777. About the year 1804 Dalton discovered that for the same quantity of carbon, the quantity of hydrogen in marsh gas is twice that in olefiant gas, and that an analogous multiplication exists in the compounds of oxygen with carbon and with nitrogen. To explain the law of multiple proportions thus discovered, he promulgated his doctrine of atoms, and made them serviceable in the conduct of analysis, by assigning to them proportional weights; the weight of the hydrogen atom being taken as unity.

But the great discovery which linked chemistry to physics, and which is rapidly creating, I apprehend, a chemico-mathematical science, was that of the combination of gases by volumes, published by Gay Lussac, in 1808. It derives additional importance from the remarkable behavior of bodies in their gaseous condition, in that they suffer an equal amount of dilation and contraction for the same change of temperature and pressure. Hence Ampère inferred that equal volumes of two gases contain the same number of atoms, and that the weights of the atoms of simple gases are proportional to their densities. For example, one measure of oxygen gas containing the same number of atoms as one measure of hydrogen, while it is sixteen times greater in weight, the weight of the oxygen atom must be sixteen times greater than that of the hydrogen atom. The value of these atomic weights was immensely increased by the discovery, in 1819, by Dulong and Petit, that these numbers represented the weights of the elements, with some exceptions, which had the same capacity for heat. This being the case, the specific heat of a body becomes a vital consideration in the determination of its atomic weight. In the following year, modern chemistry, as the science which has for its great prerogative the investigation of the nature and changes of position among *atoms*, received another vast addition in the discovery by Mitscherlich, of Isomorphism.

A great confusion now arose in the minds of chemists, and still, unhappily, prevails in many, with regard to the true signification of the terms Equivalent and Atom. It springs from the fact that the quantities of different elements which enter into combination with the same quantity of a certain element, and which are properly called equivalents, are not always the same as the atomic weights. Thus a quantity of oxygen represented by 16 enters into combination with a quantity of hydrogen represented by 2, while to saturate the same weight of hydrogen, 71 parts of chlorine are required. Hence, 71 parts of chlorine are equivalent in respect to 2 parts of hydrogen to 16 parts of oxygen; but while the atomic weight of oxygen is to be taken at that of 16. that of chlorine is but 35·5. The same is true with regard to acids and bases. After perplexing the minds of chemists for many years, the confusion is now being done away by the assignment of different equivalential atomic values. As a further consequence of this last-named distinction, the fundamental difference between atoms, in respect to their substitution value, or *atomicity*, as it has been happily called, towers into prominence.

It would be interesting to trace with the author the expansion of the foregoing ideas, and the rich fruit of high knowledge in chemistry which their full apprehension is bearing. But the foregoing will induce the chemist who desires to see the beautiful lands of promise which are now being opened out to view, rather than to dwell among the withered ideas of the past half century, to give this completest treatise on the subject of modern chemical philosophy, which has as yet appeared in English, a delighted perusal. The language is terse, the reasoning, though clear, profound. The book is a model worthy of imitation: the work of a master mind which has predicted discoveries by the *a priorie* light of logical analysis, and which has afforded to many recent theories a solid foundation of well-conceived and accurately executed experimental researches.

*Engineering Facts and Figures for* 1867. An annual register of progress in mechanical engineering and construction, with notes on the various departments of the Paris Exhibition, 1867. A. T. Fullerton. London. J. Pennington & Son, 127 South Seventh Street. Price $3·00.—Free by mail.

The title of this book gives some notion of its character, and beside the previous volumes for former years are well known and widely circulated. We may, however, remark that this volume, like its predecessors, is chiefly a condensed abstract of the more important papers on the subjects specified which have appeared during the year in the best scientific periodicals.

In the present case, we have excellent papers on the following classes of subjects, each class including more individual discussions than we could possibly here enumerate: 1. Boilers, &c.; 2. Fuel and Furnaces; 3. Steam Engines: 4. Other Prime Movers; 5. Tools; 6. Mechanical Appliances; 7. Metals; 8. Railways; 9. Marine Engineering; 10. Agricultural Machinery.

Within the very brief limits to which such a notice as the present must be confined, it is quite impossible to discuss the merits of such a book as the above, which is actually the work of an hundred authors of very various degrees of ability and information; but we can say, most emphatically, that no mechanical engineer will fail to find in it a vast amount of information of the greatest value to him in the prosecution of his business.

Among the articles which have chiefly engaged our attention, we would mention, firstly, that on boilers, including notices of the Howard, Field, Harrison, Martin, and many other special plans; a general discussion of Marine boilers, of the principles of boiler construction, and setting of vessels for generating steam at large. Secondly, that on boiler explosions, which includes some articles published in this *Journal* during the last year, and the section on Steam Engines.

We notice that the report of the Franklin Institute on the Harrison Boiler, is given in full, but as quoted in *Engineering*, without reference to this *Journal*, in which it first appeared.

On page 102, the author states that the Injector will not draw water from a greater depth than six feet, being evidently unaware of the improvement of Mr. William Sellers, by which it is enabled to raise water from a depth of sixteen feet. This improvement was exhibited in the late Paris "exposition."

Comparison *of some of the Meteorological Phenomena of* March, 1868, *with those of* March, 1867, *and of the same month for* seventeen *years, at Philadelphia, Pa.* Barometer 60 feet above mean tide in the Delaware River. Latitude 39° 57½′ N.; Longitude 75° 11¼′ W. from Greenwich. By Professor J. A. Kirkpatrick, of the Central High School.

| | March, 1868. | March, 1867. | March, for 16 years. |
|---|---|---|---|
| Thermometer—Highest—degree | 76·00° | 61·50° | 78·50° |
| “ date | 17th. | 31st. | 3d, '61. |
| Warmest day—mean | 63·00 | 53·00 | 66·00 |
| “ “ date | 17th. | 31st. | 3d, '61. |
| Lowest—degree | 6·00 | 20·00 | 4·00 |
| “ date | 4th. | 15th. | 10th, '56. |
| Coldest day—mean | 10·83 | 25·67 | 10·83 |
| “ “ date | 3d. | 18th. | 3d, '68. |
| Mean daily oscillation | 15·68 | 12·64 | 14·61 |
| “ “ range | 6.97 | 5·03 | 6·19 |
| Means at 7 A. M. | 35·55 | 34·14 | 35·82 |
| “ 2 P. M. | 46·34 | 41·29 | 46·51 |
| “ 9 P. M. | 40·69 | 37·32 | 40·37 |
| “ for the month | 40·86 | 37·58 | 40·90 |
| Barometer—Highest—inches | 30·600 | 30·485 | 30·600 |
| “ date | 6th. | 15th. | 6th, '68. |
| Greatest mean daily pressure | 30·544 | 30·450 | 30·544 |
| “ “ “ date | 5th. | 15th. | 6th, '68. |
| Lowest—inches | 29·115 | 29·430 | 29·115 |
| “ date | 2d. | 2d. | 2d, '68. |
| Least mean daily pressure | 29·249 | 29·523 | 29·241 |
| “ “ “ date | 2d. | 2d. | 22d, '65. |
| Mean daily range | 0·258 | 0·235 | 0·198 |
| Means at 7 A. M | 30·041 | 30·032 | 29·866 |
| “ 2 P. M | 30·021 | 30.002 | 29·813 |
| “ 9 P. M | 30·032 | 30·015 | 29·848 |
| “ for the month | 30·031 | 30·016 | 29·842 |
| Force of Vapor—Greatest—inches | 0·574 | 0·333 | 0·574 |
| “ date | 17th. | 1st. | 17th, '68. |
| Least—inches | ·042 | ·060 | ·023 |
| “ date | 3d. | 29th. | 5th, '58. |
| Means at 7 A. M | ·168 | ·154 | ·165 |
| “ 2 P. M | ·199 | ·159 | ·180 |
| “ 9 P. M. | ·200 | ·161 | ·182 |
| “ for the month | ·189 | ·158 | ·176 |
| Relative Humidity—Greatest—per cent | 100·0 | 95·0 | 100·0 |
| “ date | 21st. | 6th. | Often. |
| Least—per cent. | 30·0 | 23·0 | 16·0 |
| “ date | 30th. | 29th. | 31st, '60. |
| Means at 7 A. M. | 76·3 | 76·1 | 73·7 |
| “ 2 P. M. | 58·9 | 60·2 | 54·1 |
| “ 9 P. M. | 72·6 | 71·7 | 68·3 |
| “ for the month | 69·3 | 69·3 | 65·4 |
| Clouds—Number of clear days* | 7· | 7· | 9·3 |
| “ cloudy days | 24· | 24· | 21·7 |
| Means of sky covered at 7 A. M | 73·2 per ct | 75·1 per ct | 61·7 per ct |
| “ “ “ 2 P. M | 59·0 | 74·2 | 63·1 |
| “ “ “ 9 P. M | 57·7 | 61·9 | 48·3 |
| “ “ for the month | 63·2 | 70·4 | 57·7 |
| Rain and melted snow—Amount—inches | 3·80 | 5·670 | 3·442 |
| No. of days on which rain or snow fell | 11. | 18· | 11·3 |
| Prevailing Winds—Times in 1000 | N17°43′W·095 | N7° 51′ W·340 | N64°32′W·322 |

* Sky one-third or less covered at the hours of observation.

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# EDITORIAL.

## ITEMS AND NOVELTIES.

**The Cornwall Suspension Bridge.**—On the 17th of April, a Bill was passed in the New York Assembly, authorizing such works as will facilitate the construction of the Newburgh and Wallkill Valley Railroad, under the title of "The Cornwall Suspension Bridge Act." It includes, besides the erection of the bridge, the construction of 11 miles of railway to connect the Pennsylvania coal district with the New England and Western States, and, when completed, will command the whole of the anthracite coal traffic from the Wyoming, Middle and Schuylkill mines, by which a saving of 100 miles of water carriage will be effected. At present over a million of tons are annually carried down the Hudson and Long Island Sound, to be deposited at the various railway depots along the coast, whence they are conveyed throughout the States.

The great width of the river has hitherto prevented any scheme for the erection of a railroad bridge from being set on foot, and the present design is a bolder one than the great New York bridge of Mr. Roebling.

It will be a suspended girder of 1800 ft. span, placed 150 ft. above water level, and will accommodate only a single line of way. At the point selected for its erection, the Hudson River narrows into a gorge, and flows with a depth of water of 117 ft. One tower will be in 30 ft. of water, the other will be a land pier, and as the foundations are of granite, less difficulty will be experienced with that part of the work than Mr. Roebling is likely to meet with in his New York bridge. Colonel Julius W. Adams, who has just been appointed the engineer to this great work, has estimated the cost at 2,000,000 dollars. We shall publish the drawings of the bridge as soon as they are fully worked out.

**The Port of Rotterdam.**—Works for the improvement of the fluvial navigation from Rotterdam to the sea, have been pushed forward with great activity of late; and a canal, which will establish more direct communication with the sea, is expected to be opened in the course of the current year. Not only will the canal establish more direct communication between the sea and Rotterdam, but it will also enable vessels of heavier tonnage to get up to Rotterdam.

**Furnace Granite Quarries—Explosion of Three Tons of Gunpowder.**—On Saturday last, a large blast was fired off successfully at Furnace Granite Quarries, Lochfyneside, on the principle of mining and rock-blasting, introduced by Mr. William Sim, in 1853. The mines and headings on this occasion were driven in a horizontal direction from the face of the quarry, commencing at a a point about 40 ft. above the level of the quarry floor, and 80 ft. from the top. The first heading was driven inwards 46 ft., and a cross mine taken off from it to a distance of 41 ft., at the inner end of which a chamber was formed to receive three tons of gunpowder. The powder having been carefully deposited, the chamber and mines were hermetically sealed by means of rubble stone building set in Roman cement—the wooden casement to protect the wires and fuse being carried through the building in its full line of length. The gunpowder having been ignited by means of a submarine fuse, exploded without any sharp report, concussion, or stones flying, as is usual in the case of ordinary or small blasts, and displaced a mass of rock, computed at no less than 30,000 tons.

**The Mont Cenis Railway.**—Advices from Mont Cenis state that the trial trains began to run some days since between St. Michel and Susa. One engine, with a load of 25 tons, made the journey to Susa on the 20th of April, returning the following day. On the the 23d another engine performed the double journey from St. Michel to Susa and back (96 miles) on the same day, running the 43 miles in five and a half hours, including an hour of stoppages on the road. The working of the engines is said to be satisfactory. On the 1st inst. the Franco-Italian Commissioners completed their examination of the line, and authorized its being opened for goods traffic for a fortnight prior to the opening for passengers. On the return journey of the Commissioners from Susa to St. Michel, the time occupied was 5 h. 30 min., including 1 h. 15 min. stoppages. The average running speed was about 12 miles an hour.

**The Pacific Railroad.**—The rails of the Pacific Railroad were laid on the 18th of April, across the Rocky Mountain summit of the line. This point, as we learn, is 8,242 feet above the level of the sea, being the highest point reached by any railroad in the world. A distance of 600 miles from Omaha has now been reached.

**The New Freight Depot** of the Hudson River railroad in New York, is to be by far the most magnificent ever erected in this country. It extends 405 ft. on Beach and Laigh Sts., and 139 ft. on Varrick and Hudson. An area of 178,327½ square feet, or over four acres under a single roof. It is to have three stories and a basement, will be about 60 feet high from the ground, on the average, and will be composed wholly of stone, iron and brick, making it fire-proof.

**Italian Industry.**—Great efforts are now being made to develope national industry in Italy, and to put manufacturers there on a level with those of other countries. At Lodi, upwards of 100 power looms for cotton and woolens are being fixed, and will soon be ready for work. A like number are being added to a factory at Monza, near Milan. Three factories are being established at Novara, Ivrea, and Belluna. At a factory at Tolmezzo, in the Friuli, several power looms are being added. An extensive factory is being established at Pordenone. At Piazzola, Signor Camerini is establishing a spinning mill for flax and wool. The well-known woolen factory at Sehio, of Signor Rossi, is also being enlarged, and various new machines are being fixed. In Tuscany also, a woolen factory is being enlarged. During the last two months a good deal of English and Belgian machinery has been sent to Italy. The Exhibition of National Industry, now open at Turin, is a great success, and great credit is due to the committee of the *Lega Pacifica* (a league for the encouragement of national industry) who organized it on so short a notice. This exhibition will remain open until the end of June.

**Artesian Wells, Chicago.**—There are two artesian wells in Chicago, one 700 ft. and the other about 1000 ft. in depth, with a diameter of six inches. They were bored by a company of oil speculators, upon the representations of a spiritual medium, that petroleum existed in large quantities beneath. But, before they "struck ile," they had come upon water, which has ever since continued to flow almost to the full capacity of the bore. It is said that 800,000 gallons are discharged daily.

**Powerful Centrifugal Pumps.**—We notice in *Engineering* of a recent date, a description of two very powerful centrifugal pumps, to be constructed by the Messrs. Gwinne, of the Hammersmith Iron Works, England. They are intended for draining purposes in Denmark, and are to lift each 50,000 gallons of water per minute to a height of six feet. The revolving fans will be four feet six inches in diameter, and the suction and delivery pipes three feet six inches in diameter. They are to be worked by engines of 200 horse-power, and may be driven to lift 90,000 gallons per minute.

**The New Graving Dock at Malta** was inaugurated (as we mentioned in our October number for 1867), on the first of August, by the laying of the corner-stone forty-one feet below the sea level. This dock is the largest constructed. Its length on floor will be 430 feet, and coping 468 feet. Width of floor, forty-two feet; width at broad altar, eighty-four feet; depth, thirty-nine feet. The caisson for closing this new dock is under construction; the entrance is eighty feet wide. The work weighs 300 tons, and was designed by Colonel Clarke, Director of works of the Admiralty, England.

**Steam on Canals.**—A canal company has been formed to build a steam-tug, and apply it to a new plan for towing on the Erie Canal.

It is claimed that this method will reduce the cost of transportation and time occupied between Buffalo and New York one-half.

**The Water-Power of Maine.**—The reports of the hydrographic survey now going on in Maine, show that the State has 1955 sites of water-power, with a working energy of 300,000 horse-power equal to a force of 4,000,000 men. This water-power is scattered through every section of the State. Owing to the body of water in the 1568 lakes which form large reservoirs, and cover 2441 square miles, the force of the streams flowing from them is more uniform throughout the year than elsewhere.

**Hutchesontown Bridge.**—The old Hutchesontown bridge is now in course of demolition. The parapets, and part of the roadway have been removed to make way for the temporary side staging, and the arches are being centred with malleable iron frames, on rather a novel plan. These centres are two in number for each arch, and are composed of old rails, formed into a truss, placed 8 ft. apart, and secured at the crown with suitable bearing-beams, and at the centre and bottom, carefully united, so as to form a solid frame, resting on transverse sleepers placed on the footings of the old bridge. This frame being set in position, a portion of the arching will be cut off the entire face to a depth of 6 or 7 ft.; then the frame will be moved inwards to the next section, and so on. Thus the old bridge will be gradually removed only, as the permanent cylinders are set; but as it is intended to take advantage of the old structure for a service roadway, and to give partial support to the temporary staging, and works which are required for the erection of the new bridge-piers and arches, as far as this can be done, it may be some considerable time before the old bridge is entirely removed. The greater part of the cast iron cylinders are already cast, and a portion delivered on the ground, for the abutment foundations. The contractors have commenced to set up the guide, staging for the east side cylinders of the southern abutment, and have some already fixed ready for sinking. These cylinders having been sunk to the hard substratum, by dredging out the material inside, so that they may descend of their own weight to the required depth; they will be entirely filled up with hydraulic concrete. The heads of the cylinders will then be partially inclosed by a strong cast iron casing frame, and the interior filled up with the same material to the level of low water. The piers and abutment foundations will next be placed immediately on the top of this bed, and formed of freestone, and faced up with gray granite on the exteriors of piers and abutments. The superstructure of the bridge is composed of two piers and three arches of great span. The latter are constructed of malleable iron frames, and surmounted by an ornamental cast iron moulding and parapet—the centre arch bearing the arms of the city in relief. The engineers are Messrs. Bell and Miller, C.E., of this city. Messrs. Hanna, Donald, and Wilson, Abbey Works, Paisley, are the contractors, and Mr. John Kyle, resident engineer.—*Engineering.*

**New Invention for Watering and Cleansing Streets.**—Workmen are at present engaged in Buchanan Street, one of the principal Glasgow thoroughfares, laying down pipes which are to be connected with the water mains, for the purpose of watering and cleansing the causeway. The work is being done with the sanction of the police board, by Mr. Sim, who has patented the invention that is now to be put on trial practically. The pipes are of malleable iron, about 3 in. in diameter, and are laid down immediately outside the pavement on one side of the street only. The water is to escape by openings of $\frac{1}{16}$ in. diameter, drilled about a foot apart. By means of this arrangement, Mr. Sim expects to be able to lay dust at a much cheaper rate than by the old water-butt process, and he will use it in cleansing likewise in conjunction with the scavenger's broom.

**Foreign Competition with British Manufacturers.**—The *London Review* says: "An English manufacturer met a friend, the other day, in London. 'What are you doing here?' he said. The other told him, in confidence, that he was waiting to know the result of a competition for a large quantity of work. 'I fully expect the work,' he said, 'for I have tendered at a price by which we shall loose, merely to keep the works open.' The other asked if he had any objection to exchange figures with him, as the tenders were all in, and he had himself tendered for a Belgian firm. The Englishman named his price. 'You may go home, then,' said the other; 'I am 15s. a ton below you, and it will pay our firm very well at that price.'"

**The Suez Canal.**—We received yesterday some important details as to the progress of the Suez canal works. It appears, that in the month ending, March 15, the total extraction of earth amounted to 1,554,630 cubic mètres, as compared with 1,466,428 cubic mètres, in the month ending, February 15, and 1,130,386 cubic mètres, in the month ending, January 15. The quantity of earth remaining to be extracted, March 15, 1868, was estimated at 36,005,131 cubic mètres. It will be seen that the extraction is progressively increasing, and it is now calculated that the canal will be completed by the close of 1869.—*Engineering.*

**Centrifugal Pumps.**—Messrs. John and Henry Gwynne, of the Hammersmith Ironworks, have concluded a contract for the construction of two of the very largest centrifugal pumps ever made. They are for draining purposes in Denmark, and are intended to lift each 50,000 gallons of water per minute to a height of 6 ft. The revolving fans will be 4 ft. 6 in. in diameter, and the suction and delivery pipes 3 ft. 6 in. Centrifugal pumps are classed in the trade by the size of the pipes, and these are therefore classed as 3 ft. 6 in. pumps. The engines for driving them will be made by Messrs. Kitson and Co., of the Airedale Foundry, Leeds. They will be a pair of combined, horizontal, high-pressure condensing engines, with 24 in. cylinders, and 24 in. stroke, a pump being placed at each end of the shaft. The engines will work up to 200 indicated horse-power, and may be driven to lift even 90,000 gallons per minute. The works for which this powerful machinery is to be constructed are known as the Hauveille Reclamation Works.

**Photographing the Interior of a Tunnel.**—Amongst a valuable collection of scientific books, Government reports on military and engineering matters, and photographs, just presented by Mr. Walter W. Evans, president of the Spuytem Duyvil Ironworks, New York, to the Institution of Civil Engineers, is a stereograph of the interior of the high level tunnel of the Central Pacific Railroad, 7042 ft. above the sea. Every detail is clearly visible, even to the timbering of the drifted headings. The entrance to the tunnel happens to face eastwards, and the interior is sometimes illuminated at sunrise. Advantage was taken of this; and by means of a large mirror, the light was reflected equally and gradually over the whole of the interior, whilst the picture—which was exposed fifteen minutes in the camera—was being photographed.

**West Side and Yonker's Elevated Railway.**—A private trial on the experimental line on Greenwich Street, resulted in an unqualified success, and fully satisfied its proprietors. Soon it will become one of the fixed facts of the Metropolis. A speed of seven and a half miles an hour was attained, the car starting from rest, while the rope was running at that speed. No more shock was felt than in the starting of any ordinary train.

**Brooklyn Bridge** project is resting for want of funds.—The City Council deemed that they had sufficient reasons to refuse granting the 3,000,000 dollars asked for by the Bridge Company, until Mr. Roebling's plans had been approved as to construction and cost, by a competent commission. It is more than probable, that this commission will consist of Col. J. W. Adams, Mr. W. J. Mac Alpine, and Mr. Latrobe, of Baltimore.

**A New Telegraphic Cable** has been proposed to be laid between the United States and Jamaica.

**A Curious Phenomena** has recently been shown and described in the *Mechanic's Magazine*, by Mr. Gerard.—If a ring of wire, whose diameter varies regularly so that one end is very thin, is suspended over an electro magnet, it will begin to revolve. Mr. Gerard proposes to construct a new form of telegraph upon this principle.

**Petroleum.**—M. Henry Deville, in a recent communication to the Academy of Sciences, upon American Petroleum, states that petroleum increases in bulk by one hundredth of its volume for every 10 degrees cen. of heat. A due allowance for this expansion should be made in storing petroleum in vessels for fuel, otherwise the expansion is sufficient to burst the casks, thus giving rise to terrible explosions.

**Electrical Organs.**—There has just been patented in Paris, a system for applying electricity to supersede the ordinary mechanical key and draw-stop action in large organs. The patentee has already built a Grand Electrical Organ of forty-two sounding stops and eight couplers, for St. Augustin's, Paris, and another for Salon, near Marseilles. As the largest organs may be played through wires, the organist may be seated at any distance desired, and the organ can thus be placed in hitherto impracticable positions.

**Electro-bronzing.**—At the last meeting of the Institute was presented the following communication, accompanied by numerous and admirable specimens of the manufacture described:

To the Members of the Franklin Institute:—

GENTLEMEN,—By request of several members of your Institute, I submit specimens of my galvanic iron bronze.

The bronze, brass, German silver or any desired composite or simple metal, can (as is fully demonstrated by the specimen submitted, and by manufacturers in Berlin and Paris) be closely and perfectly deposited upon iron. The difficulties to be overcome are the proper preparation of the iron, so that every atom of surface presents a galvanic pole. To do this, every grain of sand and other impurity, has to be removed, which is accomplished by simple immersion in a chemical solution. Specimen No. 2, an iron star, will show you the effect; the holes in this piece of rough iron castings were moulding sand, and you will, upon close examination, see that no matter how deeply the sand penetrated the iron, it is perfectly removed without the slightest injury to the metal edges.

After the iron is thus perfectly cleaned, and all acids which may remain, properly neutralized, a galvanic coat of tin is quickly applied, and the possibility of rusting at once prevented. After being thus prepared, the copper, bronze, brass, or any other desired metal, is plated on by the galvanic battery. The solutions of composite metals, the proper use of the batteries and regulation of force, are of course a matter of skill and experience. I find, however, no difficulty and no failure. My batteries and solutions have been in practical operation all winter, and though we have covered a large surface of iron and zinc, show no diminution of force.

I submit to you another specimen, a rosette, which is our experimental subject; the outside is galvanized after being cleaned and tinned in the way described, the inside is simply galvanized with copper. This piece of iron has, as you can see, been exposed to the weather all winter; it has also undergone severe rubbings, scrapings and fumigations of muriatic and other acids, and yet the front, which was properly handled, presents a sturdy bronze front, while the back, coppered in the way more generally known, has long since submitted to its trials.

The expense of this process is small, after the solutions, batteries, &c., are practically fitted and in working order, but little skilled labor is required, and the galvanic combinations proceed day and night, without human assistance. My experience so far would make the cost of bronzing iron about equal to four coats of paint.

I also submit to your inspection, specimens of iron galvanized by contact. You will find these specimens covered with copper of extraordinary brilliancy and comparative thickness. The cost of this process is as near nothing as can well be; it is intended for common hardware, keys, locks, &c., and without claim to durability, lasts sufficiently to be useful both in the sale of goods and keeping them from rusting in handling. The iron articles to be galvanized in this manner, are simply tumbled in a box filled with sand, afterwards with leather, until they attain a bright surface, when they are suddenly dipped in a cold, negatively electrical copper solution, and the iron being positively electrical, an instant galvanic combination occurs, and the iron is covered with copper, as you see in specimens. Proper handling and quick drying are very important in this process, and I believe that the specimens submitted exceed in beauty and durability, anything before shown; they were dipped in a solution only recently discovered in my establishment by my confidential assistant, H. Flisher, to whose assistance I am very highly indebted in all experiments, for the improvement of iron products, which I am constantly carrying on.

If any experiments such as, for example, the instantaneous coppering of iron, should be of interest to your members, I shall with pleasure exhibit them to all callers.

Yours, &c., HENRI H. LOVIE,
Bronze and Iron Bronze Works, 723 Jayne Street, Philadelphia.

**Correction of Compasses on Iron Vessels.**—In the *Mechanic's Magazine*, a plan is proposed to secure a neutral magnetic chamber for the Compasses of Iron Vessels. The idea is suggested by a discovery of Faraday, who found that, if a small cubical space be enclosed, by arranging square bar magnets, with the like poles in apposition, so as to form a chamber, all local magnetism inferior in power to that of the magnets, will be neutralized. This same effect would be produced with Electro Magnetic, and it is thus proposed in the journal above mentioned, to enclose ship's compasses, as a remedy for the deviation by local attraction, the Electro Magnets to be supplied by a constant battery formed by the action of sea-water upon zinc-plates.

**Magnetic Phantoms.**—The curious and beautiful radial curves that Iron filings assume, when scattered upon a sheet of paper placed over a magnet, has been suggested in the *Mechanic's Magazine*, as a means of detecting flaws in Iron; ship's chain-cables, telegraph wires, and the like. Wherever a flaw occurs, these filings will form curves around it, and thus detect at once, the presence and the exact locality of these flaws. It is thought that in this way the too common accident of the parting of ship's cables, &c., may be readily prevented

**Elastic Chain Cables.**—At a recent meeting of the Institution of Civil Engineers, a plan was proposed to render the parting of ship's cables less frequent in storms. It is to be accomplished by having a very heavy, and powerful spring attached to the cable, so that a sudden strain may be taken up in the spring. The design appears to have been favorably received by that Institution.

**Testing Telegraph Cables.**—Under this head, an interesting paper may be found in *Engineering*, of April 24th, page 401, from which we make the following abstract:—It has long been a desideratum, in the laying of Submarine Cables, to maintain an uninterrupted series of tests for the whole time of paying-out.

Some time ago Messrs. Siemens devised a very ingenious system, whereby the tests for continuity and insulation, were alternately applied by an automatic arrangement.

The plan recently introduced by Mr. Willoughby Smith effected the simultaneous application of both tests; but no provision is made for keeping up on board the ship a "test of continuity." The "test of insulation" is kept up at one end of the cable, and the "test of continuity" at the other.

A system has lately been proposed, which has the advantage of being of unlimited application, and affording an incessant communication between the shore and the ship. The shore end of the cable being landed, the conductor, or a prolongation of it, is attached to an insulating pin, and at a suitable distance from it is fixed another insulated pin, which is connected through a delicate galvanometer to earth, between these two pins an insulated pendulum is made to vibrate.

The pendulum, on touching the pin connected with the cable, takes from it a certain portion of its charge, and during its oscillation, empties into the pin which is connected with the galvanometer.

The capacity of the pin is first fixed upon for the length and electro-static relation of the cable.

Increased capacity may be given to the pendulum, by attaching to it a condenser of suitable electrical dimensions.

It will be sufficient to insulate from the other portions of the pendulum, that part which is concerned in making the contacts.

On contact with the end of the cable by the pendulum, a momentary increase in the deflection will be observed on the galvanometer of the ship, arising from the sudden increase of capacity; and this will continue as a constant range of variation in the angular deflection due to leakage on the cable itself. By means of these slight motions, a "test of continuity," without interfering with the "test of insulation," which is always kept on the ship, the observer on shore is able to know, with positive certainty, the electrical condition of the cable, by allowing the abstracted charges to flow to earth through the galvanometer, occasionally noting the deflection. If the conductor parted, and at the same time each end remained insulated, the observer would continue to get indications on his galvanometer; but the intermittent rise and fall in the galvanometer deflection in the ship would immediately cease, and the engineer would know the exact moment when continuity ceased.

The observer on shore would very soon observe, by the deflection on his galvanometer becoming gradually, but very regularly, lessened, that the conductor had parted, and the end on shore was inclosed in the insulator. If, on the other hand, the deflections suddenly ceased, he would further know that the conductor had parted, and was exposed.

If it was required to transmit messages from the ship to the shore, it would still be possible to maintain the tests, by simply varying the battery-power, so as to alter the deflection on the galvanometer at the shore-end. Of course, this would admit of too limited a number of combinations to be of service beyond the very few signs required to be transmitted, and which should not be exceeded, if possible, during the paying out of any cable.

**The action of Ozone on Sensitive Photographic Plates.**—Dr. E. Reynolds recently read a paper, giving some very curious results on the above subject, before the Dublin Chemical and Philosophical Club. In experimenting upon this subject. Dr. Reynolds found that the undeveloped image upon a sensitized plate after exposure in the camera, subjected to the action of ozone, was completely obliterated, so that a new image might be taken upon it. This fact, Dr. Reynolds remarked, proved that the production of an image was due to a chemical action, and thus overthrows the mechanical theory of photographic images. The ozone in these experiments was obtained sometimes by the aid of electricity, and sometimes by the action of air upon phosphorus.

**American Cast Iron.**—We extract from *Engineering* of April 17th, the following testimony to the wonderful excellence of the better sorts of cast iron made in this country, which, while well known to some, is not generally appreciated. An English engineer, now in New York, writes us as follows: "The cast iron here astonishes me. I saw in the Brooklyn navy yard, a cast iron naval gun, which had been hit by a Southern shot about four feet from the muzzle, and the shot had left its mark, impressing the rifling quite clearly. There was not a crack upon the surface of the gun; but the dent was driven right through the thickness of the gun, and reproduced in the chase, so that a closely fitting shot could not be fired from it."

**Method of Repairing Puddling Furnaces.**—We observe in an article describing the Martin process for production of steel, which has just appeared in *Engineering*, the following plan for the above object. The communication with the grate or combustion chamber being shut off, the entire furnace is filled with pieces of brick and dry sand. The roof can then be removed, and a new one laid upon the sand mould thus produced, and when finished, on removal of the sand, &c., the furnace is again ready for work.

**Philosophical Society of Glasgow.**—At the last ordinary meeting of this society, on Wednesday evening last, an interesting paper was read by Mr. Mactear, of St. Rollox Chemical Works, on "The Sources from which Sulphur is obtained for making Oil of Vitrol or Sulphuric Acid." It seems that hundreds of thousands of tons of sulphuric acid are made in this country annually, and that the greater part of it is obtained by burning iron and copper pyrites, minerals which have come into extensive use since the year 1840. The brimstone which is imported, is chiefly employed in the refined state for making gunpowder. The Spanish ore, from the Tharsis mines (owned chiefly by Glasgow manufacturers and capitalists) is that variety of pyrites which is most used; it contains about 48 or 50 per cent. of sulphur and 4 to 5 per cent. of copper. Mr. Mactear gave many interesting particulars regarding the Spanish ore, and regarding the physical and chemical difficulties which are encountered in burning the other varieties of ore. Sweden, Norway, Italy, Belgium, Ireland, Cornwall, and other places are now laid under demand for the wants of the vitriol manufacturers of Britain, especially those of Glasgow and the Tyne.

At the meeting of the chemical section of the same society, held on Monday evening last, Dr. Wallace, F.R.S.E., read a paper on the animal charcoal used in sugar refining on the Clyde. For the last ten or twelve years Dr. Wallace has been very prominently identified with the chemistry of sugar refining, as an analytical and consulting chemist; and on this account, as also from the circumstance that the Clyde refiners occupy the front rank in the trade, the information contained in the paper excited a considerable amount of interest, and drew together a large number of the members.

## THE NATIONAL GOVERNMENT AND THE UNIVERSITIES.

Honesty, perseverance, and genius, are things too valuable to be lost; but our National Government is losing them and the country suffers. Herein we might learn from the monarchies of the old world. England in the nineteenth century still regulates promotion by rank, and just so far as she so does, is risking her national supremacy. We all know how essential university education is to preferment, in Prussia. France—one good at least is gained from the first Napoleon—and still more so Russia, gather in the genius of the country to the aid of despotism, and clothe their astronomers, mathematicians, chemists, philosophers and poets in golden harness, and fasten them to the imperial chariot with ribbons of honor. Even China is beyond us in this respect. A late writer in the *North American Review*, says that "Every effort is made not only to maintain thorough honesty in the customs department of the Chinese government, but to attract to it young men of high intellectual capacity, and to this end extremely liberal salaries are paid. The employees are now taken from among the best graduates of the English and American universities, the former after a severe competitive examination. After studying the language for two years at Peking, with a salary of £400, they enter active service as clerks, with salaries increasing with promotion from £600 to £1200; and when advanced to the rank of commissioners, of whom there are thirteen, they receive, according to the port, £1200 to £2,000."

In looking over a college life, it is a matter of no small pain and surprise, to see how many young men of great promise are turned adrift on graduation day, and left to wander up and down until misfortune or good luck provides them with a situation. Some men have an avocation and know it, but these are very few, aud the most seek only for an employment. Of the former, there was one among my classmates, called to be a Grecian. Not to mention other indications, he was given to chanting the chorusses from Prometheus Vinctus, Antigone, and what not, on all sorts of unseemly occasions. He hastened to Oxford, and after haunting the shades of Porson and Bentley, will return to the Greek professorship which awaits him. Then there was another who was assuredly a Latinist. But nature, with the gift, had not given its possessor a knowledge of it. I recall to-day, with pleasure, the neat turns in his translations, and the classical flow of his Latin prose. But he took perforce, a village school at Psalmaquoddy Beach, and after laying by a trifle, rose to a petty clerkship in a New York jobbing house. Then there was another, who was too proud to take a scholarship, and lived on apples and an occasional loaf of bread, smuggled home in brown paper after nightfall. Without a friend to recommend him in the town in which he settled, he earned a pittance by fitting subs for college. But why multiply instances. Rich as well as poor, and the colleges east and west, all suffer. It is a case in which our National Government might properly afford help and in so doing would be immensely benefitted. It is thought highly commendable for our government to stimulate private enterprise—even where that enterprise would of itself probably have been sufficient—in building a railroad to the Pacific. Would it be any the less so, for the government to enlist in its support the vastly more valuable and important talent that is wasted for want of proper employment? Public opinion is irresistibly marching forward to the belief that partisanship is no proper qualification for office, and the time is not many years off, when appointment to office will be made to depend upon severe examination, and the retention thereof will be for life and during good behavior. Then the government service may be freed from the foul reproach which now rests upon it, and young men of honesty and talent may embark in it as a career. Where the necessities of the case bid defiance to the corruption of political patronage, examinations even at present are requisite, and every year many of the ablest graduates of our medical colleges pass at once into our army hospitals and men-of-war. When the peril of the hour made honorable competition possible to all, the graduates and members of colleges were foremost to enlist, and at the close of the war were so universally found in high commands, as to demonstrate triumphantly the value of college drill. Now, what has worked so well in the foregoing instances, should be extended to all the departments of the executive. Who so well fitted to record observations in the National Observatory, to calculate the Ephemeris, and to make soundings for our Coast Survey, as the graduates of our colleges who have studied mathematics under Peirce, Chauvenet, Loomis, Newton, Kendall, and others? Would their study of international law, of the polity of Greece and Rome, of the history of many nations, would their familiarity with the ancient and derived languages, would their culture and gentlemanly bearing, render the scions of our citizens—Americans in the fifth generation—who graduate from our colleges, less worthy to represent us abroad, than many of our present consuls and attaches? The wholesale plunder and fraud now rife in our customs and internal revenue department is filling the country with crime, and our patriots with shame, is loading enterprise with intolerable burdens, and driving scrupulously honest men from certain forms of business. The oldest country of the globe might teach the youngest a lesson in this respect, where "the unexpected increase of the customs revenue at Shanghai, from filling the service with the best men from the English and American universities, attracted the attention of the officers of other provinces, and led to the extension of the system to every open port in China." Nor should we be blind to the advantages which would accrue from imitating the Chinese in another respect; in the foundation of professorships of the Chinese, Japanese, Hindostanee, Persian and other Oriental languages, in connection with our universities. It would not even be necessary for our government to furnish money for foundations, because as soon as it was certain that the government would employ the graduates in Eastern missions, private generosity would in this country suffice. In view of the vast number of Orientals now settled on our Pacific border, and the certainty that the commerce, wealth and population of Asia will flow in a mighty tide over our country when the railroads across the Rocky Mountains are finished, I urge the establishment of these professorships as a duty not to be delayed an hour. For proper men to treat impartially with the Indians and defend them from brutal traders, for persons keenly alive to the wants of a letter-writing people to equip our postal service, for engineers to build our ships and man the gun-boats, for purposes and positions without number, where can the government find such intelligence, Americance and fitness as our universities afford. Let it then appoint a council composed of the chief men in the National Government and representative of its various departments, like Motley, Bancroft, and Charles Francis Adams, and let them be associated with our college presidents. Let such a council appoint examining boards, devise rules for the conduct of examinations, prescribe the qualifications for success, &c. Then should we have a national government which would be stronger than steel, though without an army to defend it, because it would have enlisted in its support the moral worth, the education and the genius of the entire country.

A. R. L.

# Civil and Mechanical Engineering.

## THE SUEZ CANAL.

By Chas. H. Rockwell.

(Concluded from page 325.)

It is in this way that the site of Port Said has been raised from the level of the shallow salt lake which surrounds it; a portion of the material which has been excavated to form the channel and ship-basin at the entrance of the canal, has been used to elevate the town plot about fifteen feet above its former level; giving the foundation of an active, healthy settlement, where are now more than 8000 inhabitants. The greater portion of the excavated material will be received from the shutes of the dredges into large barges, especially provided for the purpose; of these there are two kinds. The larger ones are 142 feet long, by 23 feet beam, capable of carrying 275 cubic yards of sand, in five feet of water; the space occupied by the sand is in the centre of the boat, longitudinally, and of about one-half the total length; the material is discharged through twelve trap-doors at the bottom, six on each side of the axis; the opening and shutting of these doors being controlled by chains. The bow portion of the barge is fitted up as quarters for the crew; the stern is occupied by the boiler and engine, of sufficient power to propel the vessel five miles an hour, when loaded. In order to give increased buoyancy, there are two air chambers running parallel with the axis of the boat, through the section where the sand is deposited, the interior sides of the chambers, sloping from the gunwales towards the centre, to facilitate the discharge of the load. These barges now convey the material which is excavated to form the channel and basin at Port Said, out to sea, some four or five miles, and drop it in deep water; they will also be used in the lakes, through which the line of canal passes, where there is sufficient depth of water. The other style of barges are especially adapted for shallow water; they are smaller than the others, and can carry 125 cubic yards of waste material on a draft of less than four feet. These have their air chamber in the centre, parallel to the axis of the boat, with the trap-doors opening on the sides; they have engines, and screw-propellers, but of less power than those first mentioned, and are not calculated to go into rough water. But the great mass of the material to be excavated in forming the canal, will be discharged from the buckets of the dredges into long spouts, of heavy sheet iron, which reach over the bank on either side. These spouts are sustained by a tall frame-work of iron, which rests upon the deck of a rectangular, iron float, about 96 feet long, by 28 feet broad, requiring about five feet of water. The shape of the spout is a semi-ellipse, 5 feet wide from edge to edge, and 2 feet deep; the slope of the spouts is graduated according to circumstances, but no trouble is found in working sand or clay, when the inclination is 8 per cent. of the length; the greatest length now in use is 230 feet. The contents of the buckets of the dredge when dumped into the upper end of the spout, is forced through it by means of a strong current of water, which is supplied by a rotary pump, worked by a separate engine. The longest spouts are intended to be used in connection with the largest dredges; when thus employed, their upper ends will be about 36 feet above the surface of the water; an inclination of 8 per cent. will leave the lower end about 18 feet high; this elevation will easily clear the low bank which has been formed by the smaller dredges, in digging the channel in which the larger machine operates. The float which sustains the spout is fastened by chains and braces to the hull of the dredge, so that the direction of the discharge through the spout can be changed, and its distance from the bank can be regulated by the guiding-chains, which are laid out to anchors, on the four sides of the principal machine. The extreme width of the canal will be 330 feet, as before mentioned; by means of these long spouts, a dredge can work in the centre of the channel, and at one movement can dispose of the excavated material at a good distance beyond the water line, on either side. Another advantage in the use of this apparatus has been found in the very gentle slope which is taken by the sand when thus discharged. The quantity of water pumped into the spout is as great as the amount of sand, so that the material escapes in a semi-fluid state; and the water sweeps the sand along with it to a very considerable distance, before depositing it. There has been found no difficulty in thus disposing of 200 cubic yards of material to each lineal yard of canal. This system of the spouts is considered as the especial invention of Mons. Lavalley; he has also devised means of dumping the sand over the banks in places where the cutting of the canal brings the dredges too low to render the spouts available. This is done by an inclined plane, or traveling elevator, which consists essentially of two lines of iron rails or beams, about 160 feet in length, placed at an inclination of one to four, and sustained in the middle by a frame of wrought iron, which rests on a car, running on rails laid along the bank of the canal, and elevated about 6 feet above the surface of the water. The lower ends of the rails or beams overhang the water, and are still further supported upon a rectangular float, which also carries a steam engine. When in operation, the apparatus is placed at right angles to the axis of the canal; the inner or lower ends of the inclined plane is now about 10 feet above the water, while the upper end is some 36 feet higher, and distant 140 feet, horizontally, reaching over the bank which has been already formed. A barge containing 7 of the large boxes, before mentioned, is now floated under the inner end of the plane, and one of the boxes, filled with sand, is raised on to a truck, which runs on the inclined beams; an endless wire rope draws the loaded truck to the upper end of the beams, where the contents of the box are dumped over the bank. These are the means which will be employed for digging all those portions of the canal where the earth is not more than 6 feet above the water line; amounting to a total distance of about 76 miles. The quantities to be moved are nearly as follows, viz: seven million cubic yards, by the sand boxes and elevators; thirteen million for the barges; and thirty-five million for the spouts; being a total of fifty-five million cubic yards.

At those points where the cutting exceeds 6 feet, the preliminary work must be done by hand labor, before the dredges can be made available. As before mentioned, the deepest cut will be at El Guisr, about 66 feet above the water line; here was concentrated the great mass of *Fellahs*, for about three years; and this is almost the only spot where any real amount of work was done by them. They cut a narrow channel through this ridge, down to a level a little below the water line. When work was resumed upon the new basis of steam power and paid labor, a contract was made with Mons. Couvreux to complete this deep cut for ten and a half million francs; and he is now doing the work with locomotives, which haul a train of loaded cars out of the excavation; the cars being loaded by hand. Except this point, the contract of Messrs. Borel and Lavalley, covers the entire line of canal. The only section where *they* have been obliged to dig by hand labor below the water line, is at Chalouf, the narrow ridge at the southern end of the Bitter Lakes. Here their borings discovered a stratum of sand-stone about 10 feet thick, nearly at the bottom of the canal; its extent was not great, as it soon pitched below the required level. The quantity of rock excavated was about 34,000 cubic yards, covered by 165,000 cubic yards of sand and clay. The material here, was drawn out of the cutting upon 5 inclined planes running directly up the bank at right angles to the axis of the canal, and about 250 yards distant from each other; the motive power being a stationary engine at the top, drawing up two cars at a time, each containing about 4 cubic yards. The line of the fresh water canal was not far from the ship canal, at this point, and some trouble was experienced from the infiltration of water. This was soon remedied by means of three large rotary pumps.

On those sections where the surface of the ground is elevated above the reach of the dredges, the preparatory work is done by Arabs; these men swarm in from the surrounding desert, and work exceedingly well, taking small tasks or jobs. The engineers having carefully measured the quantity of earth to be moved, name the price which is to be paid for it; reference being had to the nature of the soil, as well as the distance to which the material must be transported. The company furnish all necessary tools, wheelbarrows, running-boards, &c., and name such a price for the job as will give the men about three francs for a day's work; they usually earn more than this, as they work hard, and almost uniformly finish their task before the time appointed. These men are exceedingly avaricious and fond of money, but are generally quiet, peaceable, and easily controlled; there are now probably ten thousand of them employed along the line, and this number could easily be increased if desired. But few European laborers are engaged in the actual digging of the soil by hand labor; the Arabs, Egyptians and Syrians having almost a monopoly in this department. The masons, carpenters and machinists are mainly Italians, Austrians and Dalmatians. The men who are employed on the dredges are mostly Greeks, under the direction of French engine-men and chief artizans. The staff of engineers in charge of the work, the clerks, cashiers and warehouse-men, are nearly all French. The general state of health among the workmen is very good [illegible] mortality being only one and one-third per cent. per annum. Of the total amount of excavation to be done to complete the canal according to the plans adopted, only about one-third has yet been accomplished; but still, the enterprise as a whole, is looked upon as being more than half finished. An immense amount of labor has been done in works of a preparatory nature, and the contractors are now in a position to push ahead with rapidity. Mons. Lavalley has stated that their outlay for machinery had already exceeded ten million dollars; besides a million and a half of dollars for preliminary expenses, such as machine shops, dwelling-houses, wharves, &c. They will have at work within a few months, 60 of the large dredges, and 16 of the smaller sizes. Of the former, 20 are to be fitted with the long spouts, and are each calculated to raise 440,000 cubic yards of material per annum. The other 40 large machines will be attended by 110 of the steam sand-barges, to transport their product. These dredges will lose some time in shifting their spouts from one barge to another, and are counted upon for a less net result, than those with the spouts, viz: 375,000 cubic yards each per annum. These results, with the assistance of the smaller machines, will make a total of twenty five million cubic yards per annum; so that there is every prospect of the completion of the canal in the autumn of 1869. The aggregate force of the steam-engines which will be employed when all the machines are at work, will exceed ten thousand horse-power. By means of the narrow channel through the ridge of El Guisr, there is salt water communication from Port Said to Lake Timsah, and from thence by the fresh water canal to Suez. Through this shallow, crooked passage, Mons. Lavalley has sent his dredges; four of them are now at work in the Red Sea, five others are at a point some ten miles from Suez, floating in a section of the ship-canal, now filled with fresh water; while six more are doing good service at Serapeum; an artificial lake having been most skillfully formed there, and filled from the fresh water canal, at a height of 12 feet above the sea level.

The objections which have been urged against the impracticability of the Suez canal, are now found to be almost wholly without foundation. The drifting of the sand in the desert has been carefully observed and calculated; and so little does it amount to, that Mons. Lavalley declares, that with a *single one* of his dredges, he can keep the channel clear, and maintain the full depth of water throughout the whole length of the canal. The opponents of the enterprise have always laid great stress on the mud from the Nile, which would be carried eastward by the currents in such quantity, as to fill up any harbor which might be dredged at the Mediterranean entrance. The experience at Port Said during the past six years, has removed all anxiety on this score; there being no deposit at all. This is [illegible] one of the best harbors on the Egyptian or Syrian coast, as vessels drawing 15 feet of water, can run in, in any weather; there were 861 entries at the port in the year 1866. During the summer of 1867, the channel will be deepened so as to admit vessels of 21 feet draft; during 1868, the depth will be increased to 25 feet, and a still greater depth will be afforded, sufficient to admit the largest class of merchant vessels, in 1869. There seems to be scarcely a doubt but that the canal will soon be completed, so as to afford a safe and easy passage between the two seas, when it will present a most striking evidence of diplomatic tact and perseverance on the part of Mons. de Lesseps, and of engineering skill by Mons. Lavalley.

It is hardly possible to say what effect this canal will have on the commerce of the world. It is almost certain to change the direction of the greater part of the shipments made between Europe and the East Indies, and must have, too, a marked influence on the United States trade with India and China.

The company are allowed to charge ten francs per ton, on all vessels passing through the canal; and if the amount of tonnage which now doubles the Cape of Good Hope should be diverted into this channel, this long-talked of enterprise will prove a great financial success.

## TELESCOPIC MEASUREMENT IN SURVEYING.

By Benjamin Smith Lyman, Mining Engineer.

Read before the Franklin Institute, at the Stated Meeting, March 18th, 1868.

(Concluded from page 319.)

Instead of reading the distance directly on the rod by the telescope, a movable target may be used with a vernier. One cross-hair is sighted at the zero point on the rod, or at a fixed target, and the movable target is moved to correspond with another cross-hair, and the space cut off in this way on the rod is read by the rodman; and if a vernier be used, can easily be read to a thousandth of a foot, if desired. Such a rod was used in the fall of 1862, in a topographical survey in Schuylkill County, with a measuring telescope that magnified about ten times attached to a light compass. There were three horizontal cross-hairs, not adjustable, but fixed, by chance, at such a distance apart that two inches on the rod between the middle cross-hair, and either one of the others corresponded to ten feet of distance on the ground.

The exactness of this measurement was satisfactory, but the moving of the movable target was so tedious, that the next spring a rod was made for similar topographical use, so marked that the distances might be read directly with the same telescope. The numbers of every other division on the rod were indicated by diamond-shaped spots, two-fifths of the division in diameter, and placed on either side of a dividing line, with one point at one-fifth of the division from that line, and the opposite point at twice that distance from the next line; so that the whole of each division was easily divided by the eye into ten parts, by halving the side of a spot or halving, or quartering the space between the spot and a dividing line. The cross-hairs were put nearer together, too, so as to bring them further from the outer edge of the field. It was wished to have them just half as far apart as before; but they proved to be so far apart, that $\frac{36}{35}$ of an inch on the rod corresponded to ten feet of distance, and the rod was divided accordingly. This telescope and rod were used very successfully through the summer and fall of 1863. The first part of the season, the levels were taken by means of angles on a vertical circle, as they had been the year before; but after that, to avoid the uncertainties and excessive office work of that method, an ordinary level-rod was carried, besides the one for measuring, and the level was taken in a separate observation for each station with the help of a spirit-level attached to the telescope of the compass. The running, in such a case, is done with front and back sights, like leveling, with one rod; and, as the sights are level, no correction is needed for slope. The exactness of these methods, even with so slight an instrument as the compass was, and their thorough satisfactoriness in that respect for geological purposes are illustrated by the fact that a shaft was sunk, in 1866, in Cape Breton, at a point where it was calculated by a map constructed, in 1863, from materials obtained in this way, that the bottom of a certain coal-bed, dipping about one in ten, would be 180 feet deep, a point about three-quarters of a mile distant from the nearest exposure of the bed, when the map was made; and the depth proved, in fact, to be 182 feet.

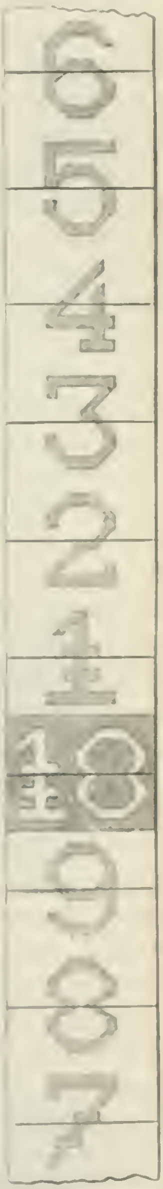
The next winter a new rod was made and divided into feet and tenths of a foot, and marked in the same way as the other had been.

Also, the measuring cross-hairs in the telescope of a new transit, with a magnifying power of about ten times, were made adjustable by screws, so as easily to be placed just so far apart that one foot of space cut off on the rod by two near cross-hairs should indicate a distance of one hundred feet; and the rod could be used at the same time for leveling, as there was a level on the transit telescope. This apparatus was used very successfully through the summer and fall of 1864, and again in the fall of 1865. In measuring important lines, every measurement was checked by a double observation, and every compass-angle roughly checked by reading also the angle of the vernier plate; so that no station was left until it was seen that no important error in reading had been made; a mode of checking that is much better than running over a line a second time. The screws that adjust the measuring cross-hairs are just behind the screws that adjust the middle horizontal cross-hair; and as the upper one was found to be exposed to being struck and turned by the limbs of trees or bushes in carrying the transit through the woods, and so making an error in the measurements before it was discovered, a cap, open on both sides, has been put over the head of this screw, to protect it completely. The telescope of a solar compass was also furnished with one fixed and one adjustable horizontal cross-hair for measuring, and was used successfully in this way with the rod just mentioned.

The same transit was also used in the fall of 1865, with great success, for measuring underground in a coal mine, and it saved much disagreeable groping in the mud to count the links of a chain; and levels were taken at the same time, with one rod. The figures on the rod, in this case, were painted with red ink upon thin paper that had been fastened to strips of common window-glass by transparent varnish, such as photographers use on their negatives. Then another coat of varnish was poured over the paper, and another strip of glass was placed upon that. The glasses, with the paper between them, were then put into a long, narrow frame of pine wood, five-eighths of an inch thick and an inch and a-half wide in the clear, which formed one side of a long box, three inches and a quarter square inside. The box has neither top nor bottom, and its sides are so hinged together that they fold over upon each other when not in use, so as to protect the glass and take up less space. The back of the box has holes through it, to supply air to the lights; and either little mine-lamps, or candles in little tin sockets, are stuck in the wood of the back. This box was made five feet long; but for low mines one might be made much shorter, say, a lantern one or two feet long (perhaps of tin), and for leveling it could have a leg that would slide in or out, so as to raise the lantern to the required height from the ground. The inside of the wooden box may be painted white, to reflect the light well, or be lined with tin, and the outside may be painted black, so as to show less the black dirt of coal mines and the grease and smoke of the lamps.

The figures on this underground rod are the common Arabic numerals, made a hundredth of a foot thick throughout and very angular, so that each hundredth of a foot in their height is marked by an angle. Every tenth of a foot is marked with a number, instead of every other division, as on the two other rods. The feet are marked by the same figures, but they are made white on a red ground; and the red ground reaches half a tenth of a foot each way from the foot-mark, so that the feet are very conspicuous at a distance. The rod for use with the transit above ground has now been repainted with these figures, as they are much more convenient for reading. They are cut in a stencil-plate, and are, therefore, easily marked on the rod; it would be still more convenient to stamp them with a die. They are eight hundredths of a foot long, four hundredths above and four below the line, and the fifth is easily estimated by the eye at half-way between one figure and the next. Of course, a land surveyor could have the rod divided into links and portions of a link, and marked accordingly; or he could so adjust the cross-hairs, that a foot on the rod would answer to a chain on the ground.

The rod is, then, in effect, marked with divisions a hundredth of a foot apart, and a telescope that magnifies ten times should, for distances less than a furlong, be exact to $\frac{1}{2400}$, that is, at most, about three inches; and to $\frac{1}{1200}$ for distances between a furlong and a



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quarter of a mile; and with a telescope twice as powerful, should be about twice as exact, since the smallest divisions could be halved by the eye. The exactness, then, with a telescope that magnifies twenty times, is at least as great as that claimed for Porro's larger instrument. Telescopes that magnify only ten times, with this rod, would measure, on the whole, much more exactly than the chain. Of chaining, Wm. A. Burt writes as follows, in his "Key to the Solar Compass," p. 35.

"Measurements with the chain and tally-pins are often very imperfectly performed by the chain men, and much more error is made than is generally supposed. It has been found by many trials, with as good men as can generally be obtained, that with two sets of chain men, instructed alike in the proper manner of keeping the chain level and straight on the line, and of setting the tally-pins plumb, as well as holding the ends of the chain to them, a difference has sometimes been made of 36 links," ($\frac{9}{2000}$) "and an average difference of 15 or 16 links to a mile" ($\frac{1}{500}$), "in common timbered land. But repeated measurements over the same mile, by the same chain men, and near the same time, will generally agree within 5 links" ($\frac{1}{1600}$); "yet, after several months' employment in the field, a measurement of this line may not agree so exactly. Again, the same chain men will make a different measurement to some extent, over swamps, marshes, wind-falls and thickets, when there is snow on the ground, and when there is none, in cold and in warm weather, effecting a change in the length of the chain, and by measuring fast or slow, the amount of error to each would be difficult to estimate."

It is seen that only in rare and favorable circumstances can a mile generally be chained within $\frac{1}{1600}$ of a second chaining. This precision of $\frac{1}{1600}$ is not more easily got by chaining, therefore, than the precision of $\frac{1}{2400}$ is got in measuring a furlong, at a single sight, with a telescope magnifying ten times; so that this telescopic measurement is at least one-half more exact than the chaining. But, as the error in reading the distance with the telescope is just as likely to enlarge as to lessen the true distance, the errors of several sights would tend to balance each other; in fact, the precision would increase as the square root of the number of sights. A mile measured in eight sights of a furlong each would be almost three times as exact as one sight, say within $\frac{1}{7000}$. A mile measured in ten sights of 528 feet each would, with the same care, be exact within about $\frac{1}{7500}$; with twenty sights of 264 feet, within $\frac{1}{11000}$, or less than six inches. The exactness with a telescope magnifying twenty times would be twice as great. The striking advantage of the instrument, then, for exactness is unquestionable; indeed, as the exactness might be still further increased by measuring a number of miles in one line, and by painting the rod in black and white (the best colors for distinct visibility, and twice as easily seen as the red marks have been reckoned), the instrument is well fitted even for quite exact geodesical measurements. The ease with which the measurements can be checked, so that large errors of reading are avoided, should also be borne in mind.

The general ease and quickness of telescopic measuring has always been recognized. The delays of chaining are saved; at the expense, however, of an addition to the telescopic work. Not only is the great trouble of training chain men avoided, but instead of two chain men with a rod, only one rodman is needed, whose duties are so simple (merely to hold the rod plumb in a good place) that he can also serve, at times, as axe-man. As the observations at the instrument are more numerous, it is the more desirable, though not absolutely necessary, in topographical work, to have an assistant to make all the readings to be noted by the head of the party.

The adjustableness, then, of the cross-hairs, and the easily legible marking of hundredths of a foot on the rod, by means of angular figures, or otherwise, make even greater exactness attainable than by Porro's improvements, without the excessive complications of his instrument, or its niceties in workmanship; and, at the same time, permits both leveling and measuring with only one rod. The rod lighted inside makes telescopic measuring and leveling easy underground, where chaining is peculiarly disagreeable. Such measuring is far more exact than chaining, as well as quicker and easier.

## PNEUMATIC BRIDGE FOUNDATIONS.

### PART I.—TUBES.

**THE** very general attention and inquiry, excited among engineers and railway men, by the very interesting paper upon pile support, published by Hon. W. J. McAlpine in the February and March numbers of this *Journal*, and the somewhat inaccessible manner in which the latest information concerning the pneumatic process is scattered in various publications, make it probable that additional details of the methods employed in Europe, and of some of the recent modifications of the process on the continent, may not prove uninteresting.

The following accounts have therefore been compiled from M. Perdonnet's works on "Railways;" M. Cézanne's "Account of some Russian Bridges;" M. Vuigner's "Rhine Bridge at Kehl;" M, Colburn's Paper "Engineering," and other sources.

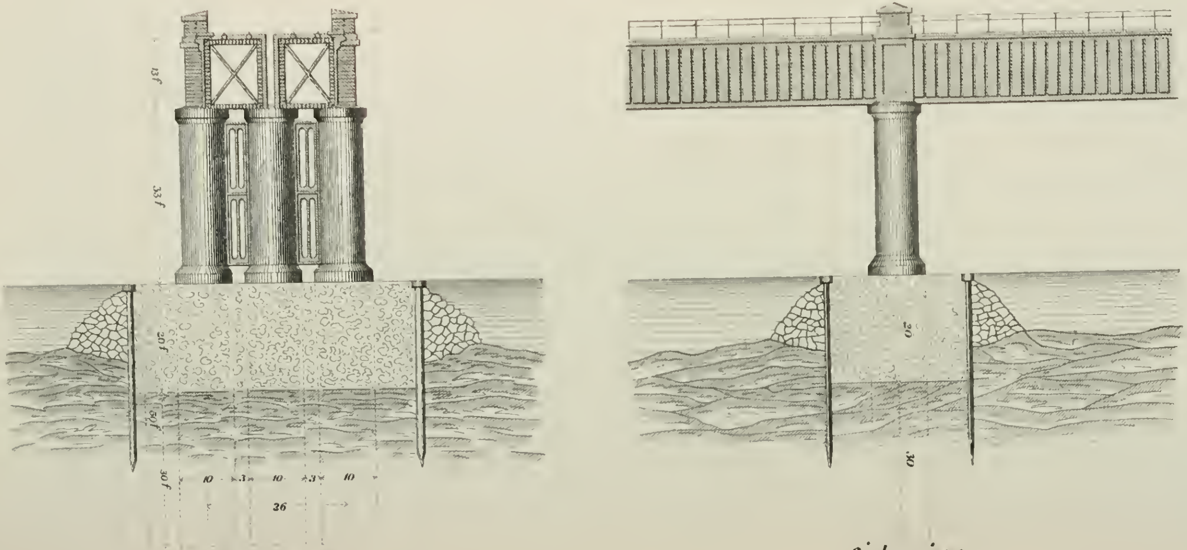
The plenum pneumatic process, first introduced by M. Triger, a French engineer, in the sinking of coal shafts from three feet four inches to six feet diameter through very wet soils, was first applied to bridge foundations by putting down a number of tubes in groups or clusters, to support, or to form a pier. Thus at the Rochester bridge, fourteen columns seven feet in diameter, support a grillage, upon which is erected a masonry pier seventy feet long, and seventeen feet eight inches wide. At the Chepstow bridge, the pier is composed of ten columns six feet four inches diameter, of which six are carried up to the bridge seat.

It was soon found, however, that but one tube could readily be sunk at a time; that in placing them close together, the putting down of one column was liable to disturb those already sunk, and that there was a manifest advantage in reducing the number and increasing the diameter.

The continental engineers having put down a good many foundations by this process of late years, a description of a few of their works may be more interesting than that of the better known English examples.

*Mâcon Bridge.*—At the Mâcon bridge, over the Saône, in France, instead of masonry piers, the cast iron cylinders were carried up to the bridge seat. Plate No. 1 gives a side and an end view of the pier. Three cast iron columns, ten feet in diameter, and one and a half inches thick, placed thirteen feet between centres, were sunk from thirty-two to forty-feet in the soil, to a depth of fifty feet below low water. Above this they are surmounted with smaller tubes eight feet three inches in diameter, joined with the foundation tubes by a conical base, and carried up thirty-three feet above low water. The whole foundation is protected from injury by a mass of concrete nineteen and a half feet thick, inclosed in sheet piling; and above this the tubes are thoroughly braced together. The columns are filled to the top with concrete, which is capped with cut stone

## Pier of Mâcon Bridge over the Saône.



End view

Side view

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to receive the bearing plates of the trusses. The bridge consisting of boiler plate girders for double tracks, the centre column carries two trusses, and the outside, one truss each.

The main difficulty met with in the execution of this work, which was carried on in a comparatively tranquil river, seems to have been in apportioning at all times the weight, to the friction of the tube against the soil and the reaction of the compressed air. Sometimes no amount of weight could start the column for a while, when it would suddenly go down several feet. At other times the buoyancy of the air would drive the column up, and pressure had to be diminished.

One of these columns having been broken by the shock of a passing boat, engineers have since generally adopted a greater thickness than one and a half inches, for all parts exposed to similar accidents.

Similar foundations were put in for a bridge over the same river at Lyons.

*Theiss Bridge.*—At the bridge over the Theiss, at Szégédin, in Hungary, built by M. Cézanne in 1858, the very bold expedient was adopted of putting down columns of the same dimensions as those at the Mâcon bridge, to carry a series of wrought iron arches of 136 feet span for a double track railway bridge.

The piers consist of two columns, each ten feet in diameter, placed thirteen feet between centres, the centre of each column coinciding with that of the track it carries. They are sunk to a depth of thirty-nine feet below low water, or about twenty-nine feet through the soil. After the tubes were sunk by the plenum process to the desired depth, wooden piles were driven inside of them, to a further depth of twenty feet, to consolidate the bottom, and support the concrete, with which they were filled up to low water.

As it would have been difficult to make a satisfactory connection between the tubes and the arches, they were surmounted above low water with a square shell of wrought iron, thoroughly braced and filled in with masonry, which receives the springing of the arches.

The foundation columns are protected by a timber ice breaker, and are surrounded by concrete and rip rap enclosed in sheet piling.

In order to relieve the piers as much as possible from the thrust of the arches, the square wrought iron portion of the tubes is carried up as high as the crown of the arches, and connected with a horizontal chord extending the whole length of the bridge.

It is found, however, that the passage of a train springs the tops of the columns, as the load successively rests upon each span, and that variations of temperature produce deformations of the piers and of the arches at the springing, so that the permanent stability of this work has been questioned.

*Bordeaux Bridge.*—The method of sinking all these tubes, was that of suddenly restoring gravity to the column, by allowing the compressed air to escape, after having excavated inside as deep as possible, and loaded the tube on top to overcome the adhesion of the soil. This process, however, results in a series of rapid descents or jumps, during which it is difficult to keep the column vertical; the staging occasionally proving insufficient to prevent lurches and settling out of line of the tube. At the Theiss bridge, it was found necessary on one occasion to unload and raise a tube several feet, in order to restore it to the proper line, while the scour of the soil and water under the lower edge, as they rushed into the column at each sinking, loosened and disturbed the adjoining tube, and considerably increased the cubic contents to be removed.

In order to avoid these difficulties, at the bridge of Bordeaux, over the Garonne, built in 1859 and 1860, by Messrs. Bommart and Surrel, engineers, the tubes were forced down without intermitting the air plenum, by hydraulic presses erected upon the staging.

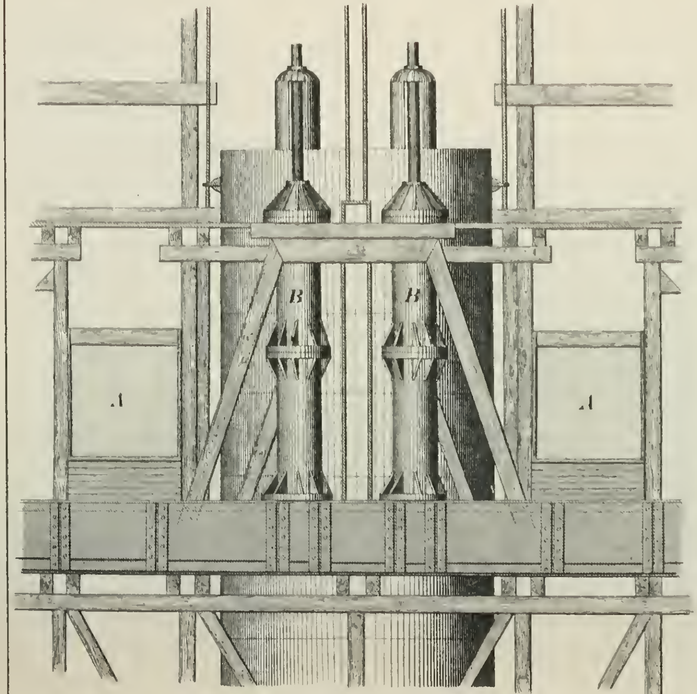
Plate II. shows the process adopted. The piers are composed of two cast iron columns, each eleven feet nine inches diameter, throughout their whole height, and sunk to a depth of fifty-two feet below low water. They are formed of a series of full cylinder sections, each four feet eight inches high and one and a half inches thick, bolted together through inside flanges, and filled with concrete.

The columns are united by strong diagonal bracing, and carry a double track railway bridge on two trusses. It was at first intended to protect them from shocks of passing boats, by iron starlings resting upon smaller columns above the main pier, but these were omitted in the execution of the works.

In order to sink the tubes, sufficient weight was placed in ballast boxes, resting on the staging, as shown at AA., to overcome both the friction of the soil, and the buoyancy of the compressed air. Four hydraulic presses, BB. were suspended in pairs on each side of the tube, by cross girders resting upon its top section, and were connected with the ballast boxes below.

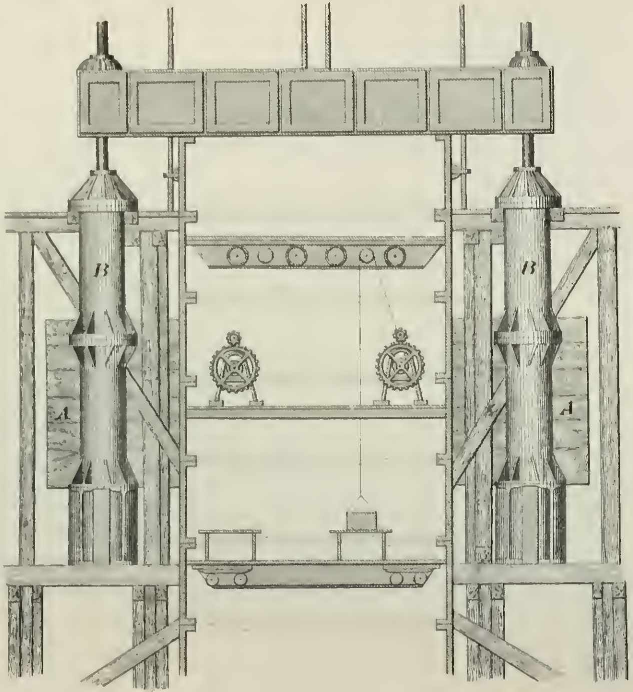
By working the pistons of the hydraulic presses, they tended to

# Bordeaux Bridge



Side view

Method of Sinking tubes.



Section through tube

[illegible] M[illegible], Philadelphia

lift the ballast boxes from the staging, and transferred their weight to the tubes, and by operating with either one or both pairs of presses, the exact weight required at each stage of the operation was obtained, and the column put down as fast as the material was excavated inside, without intermitting the plenum or allowing the compressed air to escape.

This modification, which secured perfectly vertical and nearly a uniform rate of descent, is, however, not only more expensive than the ordinary method of intermitting the air pressure, but also compels loading the tube with much greater weights, in order to overcome the reaction of the compressed air, as well as the friction of the tube; and these great loads upon the empty shell, may cause fracture. On one occasion, one of the sections of the tube composing the air-lock, and one and a half inches thick, burst, and the fragments were projected outward by the air pressure.

On another occasion, one of the tubes which was in process of sinking, broke from its fastenings to the hydraulic presses, and was raised by the reaction of the air fifteen or twenty feet.

There are at this bridge six piers, each formed of two columns spaced twenty-six feet three inches between centres, and the sinking of these twelve tubes occupied thirteen months, while the whole structure occupied twenty-three months in building; this time being nearly an average of that occupied by recent works of this character in Europe.

*Saltash Bridge.*—We translate the following from M. Perdonnet's work upon "Railways." "The sole pier of the Saltash bridge was founded upon a rock at a depth of eighty-two feet below high tide, covered with seventeen feet of soft mud. Mr. Brunel decided to build a sheet iron cylinder eighty-eight feet in average height, so as to project six feet above high tides. The rock, however, sloped, so that it was necessary to cut the base of the cylinder off at an angle, and fit it to the shape of the rock as near as possible.

The cylinder was thirty five feet in diameter at the bottom, and so constructed that the pier could be built inside of it up to the water-line; above this, it was to be surmounted with four cast iron columns, carrying the trusses of the bridge, which are each of 455 feet span. The problem, therefore, was how to ground the cylinder, to fit it accurately to the rock so as to shut out the mud, and how afterwards to clean it out and build inside as in a coffer-dam.

(To be continued.)

# PECULIARITIES OF THE LINK MOTION.

By A. Dunbar, Second Assistant Engineer U. S. N.

The link motion, as applied to a numerous class of engines for screw vessels in the Navy, is the type upon which the following deductions are based:

To render them more simple, they will be divided into four parts, viz.:—*First*, Radius of Link. *Second*, Variation of Lead. *Third*, Point of Suspension. *Fourth*, Effect of the point of attachment of the excentric rods to the link upon the point of cutting off.

*First.* The radius of the link is correct, when the lead increases or decreases equally upon both ends of the stroke throughout the movement of the link. With the dimensions commonly used, it is the distance from the centre of the link-block to the centre of the excentric, less three quarters of the lap and lead of the valve. Reference to this will be made in the second part of this paper, in order to dispense with a diagram to illustrate this point.

*Second.* The lead increases, when the link is moved from full gear into mid gear, if the excentric rods are *crossed*, when the crank is on the centre next to the cylinder, and decreases, if they are *not crossed* under the same circumstances.

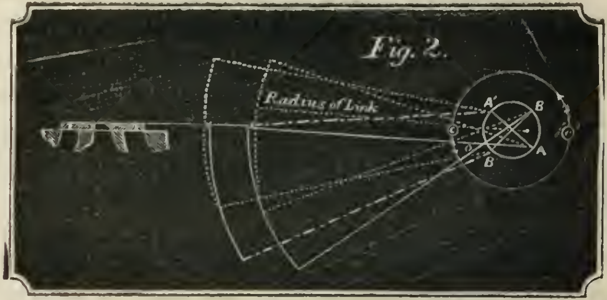
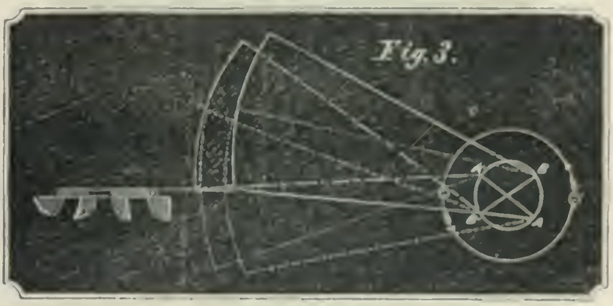


*Fig. 2.*

In Fig. 2, A and B, are the positions of the centres of the forward and back motion excentrics, when the crank is on the centre, C, next to the cylinder. The direction in which the crank moves forward, is indicated by the arrows.

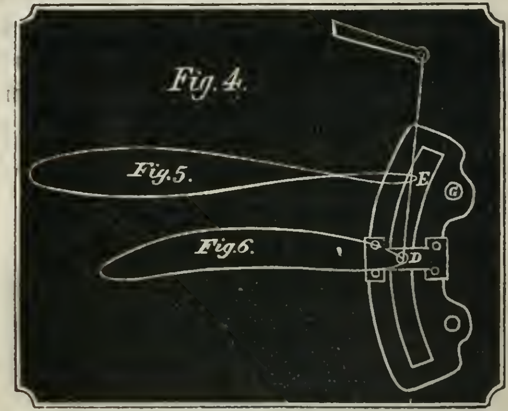
The full lines represent the position of the excentric rods and link, in full gear forward motion, crank on centre, C, and the broken lines, the position of the same in mid gear, crank on centre, C. By inspection, it will be seen, that when the link is drawn up into mid gear, the valve has opened the outboard port, and increased the lead equal to the distance, X. In these diagrams, the valve is supposed to be without lead, when the link is in full gear. The uneven broken lines represent the position of the excentric rods and link in full gear, forward motion, crank on centre, C′, and the even broken lines, the position of the same in mid gear, crank on centre, C′. By inspection, it will be seen, that when the link is drawn up into mid gear, the valve has opened the inboard port, and increased the lead equal to the distance, X′; as X and X′, are equal, the radius of the link, is correct. If they were not equal, it would be necessary to divide the difference, and through that point and the extremities of the link, draw a curve, the radius of which will be the true radius for the link.



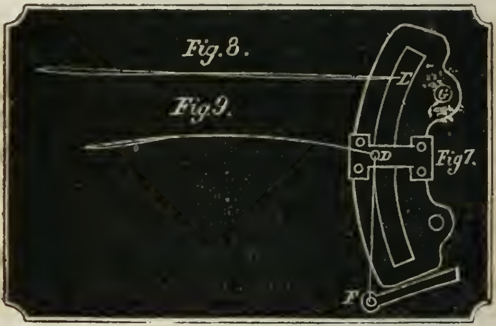
In Fig. 3, A and B, are the positions of the centres of the forward and back motion excentrics, when the crank is on the centre, C. The full lines represent the position of the excentric rods and link in full gear, forward motion, crank on centre, C, and the broken lines, the position of the same in mid gear, crank on centre, C. When the link is lowered into mid gear, it will be seen, that the valve has moved over the outboard port, and the lead is a negative quantity equal to the distance, X. The uneven broken lines represent the position of the link and excentric rods in full gear, forward motion, crank on centre, C′, and the even broken lines, the position of the same in mid gear, crank on centre, C′. As on the other centre, when the link is lowered into mid gear, the valve has moved over the inboard port, and the lead is a negative quantity equal to the distance, X′.

In Fig. 2, the excentric rods are *crossed* at O, when the crank is on the centre next to the cylinder, and in Fig. 3, they are not *crossed.*

*Third.* The point of suspension should be so arranged, that the slip upon the link-block should be the least obtainable in practice, that the wear upon these parts may be as slight as possible, for they are generally so constructed, that the lost motion in these parts can only be taken up by substituting a new block.



If the point, D, (Fig. 4,) moves in an arc whose concave side is up, as is ordinarily the case, and as there represented, the point, E, will, if the drawing be enlarged eight times, develop a figure as shown at Fig. 5. If the point, E, moves in a straight line without slip upon the block throughout a revolution of the crank, a figure will be developed by the point, D, as shown at Fig. 6 (enlarged as before). If the point, D, Fig. 7, be moved outboard upon the link-saddle, about three-quarters of the lap and lead of the valve, it will then develop, if the point, E, moves in a straight line, and the drawing be enlarged as before, a figure as shown at Fig. 9. This figure is very nearly the arc of a circle.



Find the centre of the arc that nearest approximates this figure, and we have the position of the extremity of the reversing-arm, and the length of the suspension rod.

If the point, D, moves in that approximate arc, the point, E, will develop a figure as shown at Fig. 8. As the convex side of Fig. 9 is up, the extremity of the reversing arm must be below the link, and almost under the point, D, vertically.

With these points in this position, the slip of the link upon the block, will not exceed one-fortieth the travel of the valve. The distance the point, D, has to be moved outboard upon the link-saddle varies with every variation of the length of the link compared to the travel, and lap and lead of the valve. The author is unable to give any rule for finding this point that he can rely on in all cases. To explain the process for laying down the figure shown at Fig. 6, would extend this paper beyond its intended limit. The distance is determined from the shape of this figure, and this varies with every change in the dimensions. Those given here are for the general proportion of the "Juniata" class of engines. The slip increases as the link is moved either way from the given position, and these points should be located for the position in which the link is mostly used. The extremity of the reversing arm must be in the centre of the approximate arc, for if this point does not coincide with that centre, the slip is materially increased.

*Fourth.* In engines using a slide-valve with lap and lead, the point of cutting off is generally unequal if the lead is equal, owing to the angularity of the connecting rod. If the excentric rods are attached to the link at a point inboard from the centre of the curvature of the link, as at G, Fig. 4, and the engine be back-acting, this arrangement will equalize the point of cutting off, provided the point, G, be the proper distance from the centre of the link-

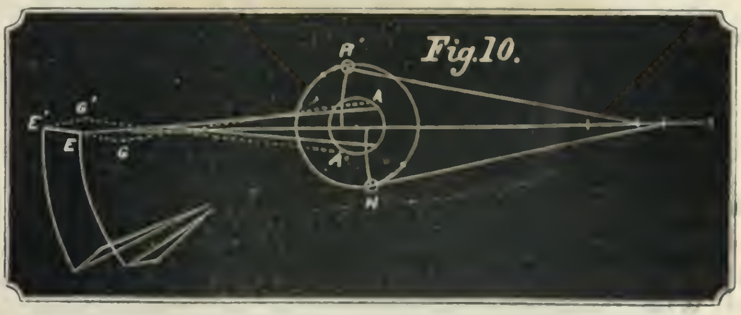


Fig. 10.

block. To illustrate this, reference will be made to Fig. 10. Suppose the point of cutting off, to be at six-tenths the stroke, and the length of the connecting rod to be two and one-half times the stroke of the piston, then the crank will stand at the point, H, when cutting off on the outboard end, and at H′, when cutting off on the inboard end of the cylinder.

The crank has moved through more than six-tenths of a semi-revolution, when it arrives at H, and as the valve moves with the crank, the valve would be more than closed, were it not for the angle, E, G, A, formed by the link and excentric rods at this time, which angle shortens the distance from E to A, and prevents the valve from closing until the crank arrives at H.

Again, when the crank arrives at H′, it has not completed six-tenths of a semi-revolution, and the valve would not have closed, were it not for the angle, E′, G′, A′, formed by the link and excentric rods at this time, which angle shortens the distance from E′ to A′, and closes the valve when the crank arrives at H′. (The point of cutting off, on the "Juniata's" engines, is within an eighth of an inch of being equal.) With the valve attached to the link, and moving coincident with it, if the engine was direct-acting, the difference in the point of cutting off would be nearly doubled; but if a rocker-shaft be interposed between the link and valve, the difference is equalized.

In the preceding parts of this paper, this peculiarity of the link motion was not taken into consideration, because the back motion, excentric rod, and end of the link makes nearly the same angle as the forward motion, at the same time, and the result is to draw the link bodily inboard, and does not materially affect the deductions then stated.

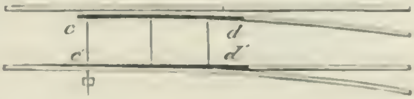
## A. F. BALLAS' PATENT R. R. SWITCH.

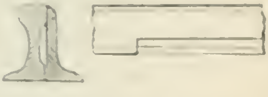
THE many accidents which occur through the switches now in use, leave no doubt that they are highly defective and dangerous. The principal objections against them are—

1st. When the switch is set for the side track, the main track is interrupted. Thus, if a switch has been left standing for the side track by the switch-tender, trains which follow the main track will be thrown from the rails.

2d. Every change in the connection of the tracks through the switch, has to be made by the switch-tender; or in other words, the switch is not self-acting.

All inventors who devised improvements in railroad switches, paid especial attention to these two points; their object was to construct a self-acting safety-switch. The best self-acting safety-switch I know, is in use on many of the European railroads, and is patented in the United States by Withcomb. C D and C′ D′ are tongues or movable switch-rails connected together by cross-rods. The end of the tongue is made wedge-shape, and adapted to fit into a notch in the side of the rail. In order to avoid strong concussions at the point of the tongue, the flanges of the wheels are guided by guard-rails on the side of the track opposite to the point of tongue. The tongues are always kept pressing against one side of the track through a lever with counter-weight, arranged in such a manner that the switch stands always for the main track. When a train is to pass from the main track to the side branch, the tongues must be pushed to the opposite side by the switch-tender through the lever; but when the train runs from the side branch to the main track, the tongues are pushed towards the opposite side by the flanges of the wheels, and go back to their old position by the action of the counter-weight, as soon as the train has passed.





These switches have undoubtedly great merits in regard to safety and automatic action, nevertheless they have not been used much in this country, and I think for these reasons: the end of the tongue is of the same height as the rail, and presents a very thin or narrow edge to the tread of the wheel, and is therefore liable to be crushed and destroyed by heavily laden trains, while the notches in the rails to receive the ends of the tongues, weaken said rail in a great degree. Then the switch is self-acting only in *one* direction. The improvements of my switch over that of Withcomb, consist—

1st. In the shape of the tongues. The rails against which they set are *not notched*, but are preserved complete, as shown by sections A, B and C′. The end of the tongue is constructed lower than the rail, and is adapted to fit snugly against the web and the under side of the tread; by these means the tongue has no weight to carry at its weakest place (from A to B), and suffers no concussion, but merely has to resist the side pressure of the flange of the wheel; it begins to carry the load of the train at B, where its tread is $1\frac{1}{8}$ inches.

2d. In the arrangement of the switch-stand and counter-weight. The counter-weight, A, is applied to one end of a rod that at its inner end is hung so as to turn upon an axle between two plates, which hang loose on the same axle. Between these plates, B, little stop-blocks for the weight-arm to rest upon; their lower end is connected through a rod, with the switch-tongues. Having the arm of the counter-weight resting on one of the stop-blocks, as shown in Fig. 2, the switch is acting in the same way as Withcomb's; trains will follow the main track in both directions, up and down, and pass from the side branch to the main track, without any assistance of the switch-tender. Turning the weight over and having it resting on the other stop-block, the switch is in the position shown by Fig. 1. In this position trains pass from the main track to the side branch, from the side branch to the main track, and can follow the main track in the direction of the arrow, without any assistance of the switch-tender. This double action of the counter-weight gives great facilities for shifting trains, and is especially of importance for railroads with one single track.

As soon as the counter-weight is turned over, a target, suitably connected with its axle through pinion-wheels, will revolve, and shows a white or other surface or light, as may be arranged or agreed upon, and thus indicate the engineer of the train how the switch is set.

Guard rails are not required for this switch.

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## AIR GUN.

It is curious to notice the manner in which improvements sometimes retrace their steps, and return to old and abandoned fields.

Thus, gunpowder was undoubtedly far in advance of any other means devised for giving motion to projectiles; but yet, the new conditions introduced in modern warlike practice, render its violence of action too destructive to the ordinance employed, when this is of great calibre, and some modification is demanded, by which a more gentle persuasive than even mammoth powder or powder-cakes,

## A. F. BALLAS PATENT R.R. SWITCH.

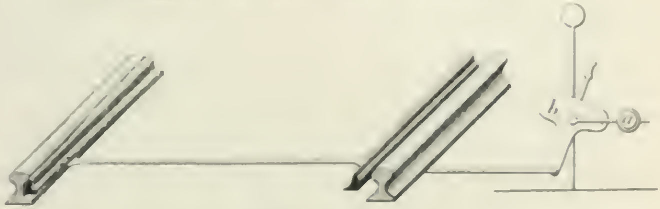
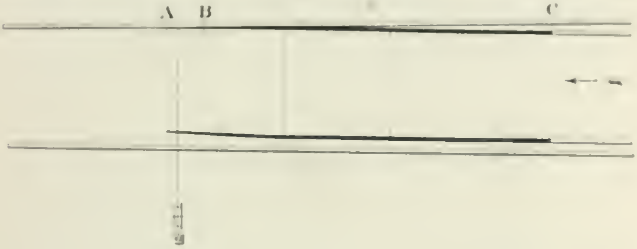


Fig 1.



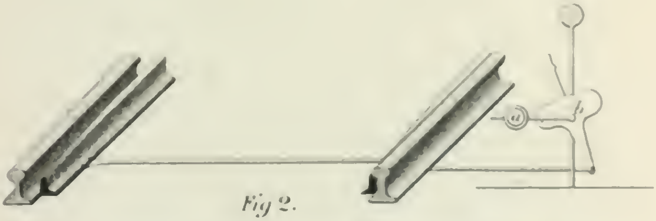
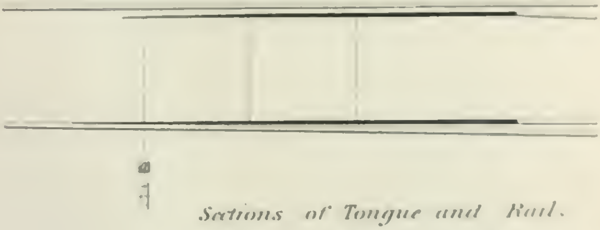
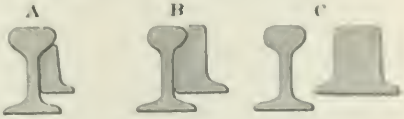


Fig 2.



Sections of Tongue and Rail.



[illegible]

may be applied to the enormous shot of 1000 or 6000 pounds, which it is now deemed advisable to hurl at an iron-cased enemy.

In a late number of *Engineering*, we find an interesting paper illustrating our remarks, a detailed account of which, we believe will be of interest to our readers.

Although with the use of gunpowder, good strong guns may be, and are made up to calibres of 15 inches, and even 20 inches; all our skill has been unable to make a trustworthy rifled gun of even 13·3 in. bore to throw a 600 lb. shot.

An enormous air gun of 32 in. bore has lately been invented, to throw a 600 lb. shot. The bore of the gun is to be upwards 30 ft. long, and the air compressed and retained at a working pressure of 10,000 lb. per square inch. The sectional area of a 32 in. bore is 804¼ square inches, and the total initial pressure would thus be 8,042,400 lb., or nearly 3600 tons. It would, of course, be next to impossible to pump in air fast enough at this enormous pressure to keep up the velocity of the shot, so the high pressure air is to be contained in a huge casing or jacket formed around the bore of the gun, and having the same capacity of say, 165 cubic feet. Thus, instead of the pressure being reduced almost to *nil* at the muzzle, the air would have been expanded but twofold on the discharge of the shot: and if we disregard the influence of rarefaction, and consequent cooling by expansion, and its effect on the pressure, we should have 5000 lb. per square inch still left. If we take the average pressure at 7500 lb. throughout the length of the bore, we shall have 2400 tons exerted through 30 ft., or say 72,000 foot tons, and this, were the air to follow fast enough, would send a 6000 lb. shot at a rate of more than 1300 ft. per second. As no ordinary valve could be opened quickly enough to admit air under such pressures, and in such quantities, the shot itself forms the valve. The high pressure air in the air casing or jacket enters the chamber of the gun through ports, like those by which steam enters a steam cylinder. The shot—a short cylinder with hemispherical or pointed ends—is so packed as to close these ports while the jacket is being pumped full. To discharge the gun a little high pressure air is separately pumped in behind the shot, so as to start it on and past the ports, when the stored-up air does the rest of the work.

Although there may be certain practical difficulties in carrying out this scheme, it possesses great interest, and we shall look with much curiosity to its practical realization.

# Mechanics, Physics and Chemistry.

## LECTURE-NOTES ON PHYSICS.

By Prof. Alfred M. Mayer, Ph.D.

(Continued from page 335.)

### 7. *Porosity.*

The spaces which exist between the ultimate parts of bodies—that is, between their atoms and between their molecules—are called *pores;* by virtue of which all bodies have porosity.

This property is a natural deduction from the properties of compressibility and dilatability; for all bodies can be reduced in volume by pressure, and this reduction of volume is only limited by the pressures which our machines can produce, and all bodies expand in volume when relieved of pressure; we therefore conclude that the ultimate parts of bodies do not touch, but are separated by intervals that we call pores.

This property of porosity, first indicated and concisely defined by Gassendi, can, however, be directly proved by numerous experiments.

Porosity of solids. Water and oil have, by enormous pressures, been forced through the walls of vessels of gold and of iron; iron converted into steel by absorbing carbon at a high temperature; gold and the densest bodies are transparent when reduced to sufficiently thin leaves; lead is so porous to mercury, that Prof. Henry made a syphon of a solid bar of lead draw mercury over the side of a vessel containing it; marble and all rocks are porous to gases, allowing them to "diffuse" through them. We can ascertain how a stone will be affected by frost, by allowing it first to absorb a solution of sulphate of soda, and then ascertaining the effects produced by its subsequent crystallization. It is better, however, to determine directly the effect of the freezing of absorbed water. See *Smithsonian Report*, 1857, p. 305. (It is probable that the two preceding instances are examples of the porosity existing between the integral crystals of the stone and not between the ultimate parts, and therefore is not porosity in the sense in which we have defined it.) Hydrophane, a species of agate, becomes translucent by the absorption of water, when immersed in that liquid, while the displaced air issues from the hydrophane in minute bubbles.

M. M. Deville and Troost have recently shown that platinum and other dense metals and cast iron, when heated to redness, are porous to gases. The injury to health produced by heating dwellings by means of cast iron stoves, is caused by the vitiation of the atmosphere by the gases of combustion transmitted through the hot iron. (See *Comptes Rendus*, Jan. 20, 1868. Report of commission on the observations of Dr. Carret, on the deleterious effects of cast iron stoves.)

Porosity of Liquids. If measured volumes of water and of alcohol are mixed, it is found that their combined volume is less than the sum of their volumes before mixing. The greatest contraction takes place when 100 volumes of water are combined with 116 volumes of anhydrous alcohol, the diminution in volume being equal to 3·7 per cent.

This experiment, due to Réaumur, is made as follows: to a bottle is adapted a deeply fitting cork, perforated by a glass tube. The requisite proportion of water is placed in the bottle, and on this, colored alcohol is gently poured until it completely fills the bottle. The stopper is now forced in, and the alcohol rises in the glass tube. The height of the liquid is marked, and the bottle being so inclined that the mixture of the liquids takes place, the fluids contract, and the alcohol descends in the tube.

Contraction also takes place when water is mixed with sulphuric acid, with salt and with other substances. No experiment could more clearly show that the atoms of water and alcohol do not really fill the space which the liquids appear to occupy.

Water and other liquids dissolve gases; for example, 1 volume of water at 60° Fah. will dissolve 720 volumes of ammonia, and increase in its volume only one-half, and in its weight one-third.

Porosity of gases. Six parts by weight of carbon will unite with eight parts by weight of oxygen, and yet the resulting carbonic acid gas has the volume of the oxygen before combination.

Air and vapor are porous to each other, and between the atoms of air there may exist the ultimate parts of other gases.

It is to be remarked that this property of porosity is not opposed to the property of impenetrability, for it is the atoms which are impenetrable, while it is the intermolecular spaces of one body which are penetrated by the atoms of another.

We must be careful not to confound the true meaning of porosity, as given above, with what we designate as *organic*, or *structural porosity.* Organic pores are interstices which are visible with the aid of the microscope, and often even with the naked eye, while the intermolecular spaces are invisible by any means.

Examples of organic porosity. Mercury forced through wood. Circulation of sap in plants.

Examples of structural porosity. Porosity of stones, caused by the minute interstices produced by the crystalline structure of the stone. Paper used to filter liquids.

### 8. *Mobility.*

Everywhere in the universe, we see masses of matter changing their positions with reference to each other; while others appear to be at rest.

We only know that a body changes its position by referring it to other bodies, supposed to be at rest; and therefore Descartes defined motion as a rectilinear change of distance between two points. From this definition, if only one point existed in the universe, its conditions, whether of rest or of motion, could not be determined.

If the points to which we refer the moving body be really at rest, then the successive varying measures give us the *absolute motion*, but if this point be only apparently at rest, we obtain the *relative motion.* Give illustrations.

Rest is however only *apparent;* we know of no point in the universe which is absolutely at rest; therefore all the motions which we have determined are relative.

All bodies on the surface of the earth have the relative positions of their atoms changed by every change of temperature, by every vibration which they transmit; they are in motion with the earth on its axis and in its orbit, while the earth with the planets and sun are being translated in an unknown path in space. The stars, improperly called *fixed*, have also motions of their own, which, in some cases, are evidently of great magnitude.

Kind of motions. A motion may be one of *translation*, of *rotation* round an axis, or of a combination of these motions; it may be *rectilinear* or *curvilinear*, *continued* or *reciprocating*. Give illustrations.

The line a point of a body describes in space, is called its *trajectory*.

The *velocity* of motion of a moving body, or the ratio of the space described to the time of describing it, may be *uniform*, *uniformly accelerated*, *uniformly retarded*, or *irregular*.

*Uniform motion* is that in which equal spaces are passed over in equal, small portions of time.

Formulæ of uniform motion.

$$(1)\quad S = VT;\ T = \frac{S}{V};\ V = \frac{S}{T}$$

in which $S$ = space described; $V$ = velocity of moving body, or the space described in unit of time; $T$ = time occupied in going over space $S$.

*Uniformly varied motion* is that in which the change in velocity at the end of a certain time, is proportional to this time.

Let $u$ be the initial velocity of the body, that is to say, the velocity at a given instant from which we commence to reckon the time; $a$ the acceleration, or the constant quantity by which the velocity varies in a unit of time; $v$ the velocity at the end of $t$ seconds: we have from definition of uniformly varied motion.

$$(2)\quad v = u \pm a\,t$$

The sign + when the motion is accelerated; the sign − when it is retarded. In the last case, the velocity will become 0 when $u = a\,t$, that is to say, at the end of a number of seconds represented by $u : a$.

If, in formula (2), we make $u = 0$, then the moving body starts from a state of rest, and we have at the end of time $t$

$$(3)\quad v = a\,t;$$

that is, *the velocity acquired at the end of a certain time is proportional to this time.*

*In uniformly accelerated motion, the spaces described by a body starting from a state of rest, are proportional to the squares of the times employed to describe them;* or—

$$(4)\quad S = \tfrac{1}{2}\,a\,t^2$$

which shows that the space gone over in uniformly accelerated motion, by a body which starts from a state of rest, is equal to the space which it would go over with a *uniform motion* with the velocity $\frac{1}{2}\,v$ or $\frac{1}{2}\,a\,t$.

It is often required to know the velocity acquired in function of the space gone over. We obtain this by eliminating $t$ in the two equations $v = a\,t$, $s = \frac{1}{2}\,a\,t^2$, which gives—

$$(5)\quad v = \sqrt{2\,a\,s}$$

A body falling vertically, in vacuo, by the action of gravity, from a height which is exceedingly small compared with the radius of the earth, may be regarded as having a uniformly accelerated motion. In this case $a$ is equal to the velocity acquired by the body at the end of the first second of its fall. This velocity which is the measure of the intensity of gravity, and which is equal, in the latitude of New York, to 32 feet 2 inches, is always indicated by the letter $g$. The formula (5) then becomes—

$$v = \sqrt{2\,g\,s}$$

*Problem.* What velocity will a body acquire by falling 772 feet, in the latitude of New York? Ans. 222 feet, 10·28 inches.

When the moving body possesses an initial velocity $u$, at the moment from which we count the time, the above formulæ become—

$$v = u \pm a\,t;\quad s = u\,t + \tfrac{1}{2}\,a\,t^2,\quad v = \sqrt{u^2 + 2\,a\,s}$$

To Galileo is due the discovery of the laws of uniformly varied motion. Give his classical demonstration of these laws.

*Co-existence of separate motions.* When a body in motion is acted on by a force, the same effect in motion is produced as if that force moved the body from a state of rest. Thus, a cannon ball projected horizontally from an elevation, will reach the ground by the action of gravity, in the same time (assuming that no air resists its motion) as if it dropped vertically from the elevation through the same height.

"A body describes the diagonal of a parallelogram by two forces acting conjointly, in the same time in which it would describe its sides by the same forces acting separately."—*Newton.*

The discovery of the law of the co-existence of motions, is also generally ascribed to Galileo (Dial. 4, Prop. 2), but Aristotle clearly announced it in his Mechanical Problems, c. 24.

The various relations of space and time can readily be represented geometrically, by making lengths of ordinates stand for velocities acquired at the end of times represented by lengths of abscissas. Thus, uniformly varied motion is represented by a right angled triangle, whose base equals in units of length the units of time during which the motion took place, its altitude, the velocity acquired at the end of this time, while the units of area of the triangle represents the distance gone through by the moving body.

The consideration of motions, irrespective of force and of the properties of matter, constitutes the part of science called *Kinematics*. (Gr. Κινησις, motion.) The ablest discussion of this subject is found in first chapter of the *Natural Philosophy*, by Profs. Thomson and Tait, Oxford, 1867.

(To be continued.)

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# FLAME REACTIONS.

BY PROF. BUNSEN.

**Translated by Prof. Charles F. Himes, Ph. D., Dickinson College, Carlisle, Pa.**

(Concluded from page 344.)

IT would lead us too far to follow the special processes which would occur upon treating more or less complex mixtures, according to the preceding experiments. It may be sufficient, therefore, to show the advantages of the methods described by a few small examples.

1. *A mixture of sulphide of arsenic, sulphide of antimony, and sulphide of tin.*

If these three sulphur compounds, extracted according to the usual course of qualitative analysis by means of alkaline sulphides and re-precipitated by acids, contain only traces of antimony and tin, the detection of the last two metals according to former methods, as is well known, is excessively tedious and uncertain. In the following way they can be detected easily, and with certainty, even if the quantity of tin only amounts to several thousandths, and that of antimony to a few hundredths of the mixture.

About three decigrammes of the sulphur compounds are roasted upon a fragment of glass,* small enough to be completely enveloped by the flame, and the few milligrammes of residue are scraped together with a knife, the moistened mass is spread upon the end of a fibre of asbestus, and a strong metallic incrustation is produced from it on a test-tube. In order to avoid a deposit of some carbon at the same time, which would impair the subsequent operations, the upper reducing flame is made so slight, that it is scarcely recognizable as a luminous point. After the incrustation has been dissolved in a few drops of nitric acid in the marginal depression of the lamp-plate, Fig. 3, the solution is evaporated, below its boiling point, by warming and blowing upon it, whereby it is concentrated upon the smallest possible space. If a drop of perfectly neutral silver solution is dropped upon the residue from the solution, just at the instant at which it appears dry, the characteristic black spot of antimonate of sub-oxide of silver forms by blowing ammonia upon it and moistening it with it, and the reaction of arsenic also usually manifests itself.

In order to detect tin, a few scarcely visible particles of the roasted sulphur compounds are fused in the upper reducing flame with a borax bead, *scarcely perceptibly* colored by oxide of copper. If the bead is placed in the lower reducing flame, it becomes ruby-red by reason of sub-oxide of copper formed; if it becomes bright-brown, blackish-brown, and opaque by reason of too copiously separated sub-oxide, it is only necessary to move it back and forth in the upper oxidizing flame for some time, and from time to time to hold it up to the light, in order to obtain the ruby-red, transparent glass, which can be destroyed in the oxidizing flame, and restored in the reducing flame, as often as desired in the way described. This reaction for tin can only be produced in the lower reducing flame of the non-luminous gas lamp, and not with the blowpipe, since by means of the latter the oxide of copper may be reduced to sub-oxide without tin.

2. *Foliated tellurium* (*Blättererz*), *containing tellurium, selenium, antimony, lead, gold, and sulphur.*

After the sulphur has been recognized upon heating by its odor, a metallic incrustation is next produced upon a test-tube, and a few drops of *concentrated* sulphuric acid are placed in another test-tube, only a little wider and somewhat shorter, and the former is so depressed into the latter that the metallic incrustation may be surrounded by sulphuric acid. Upon warming, with *slowly* increasing temperature, the selenium manifests itself at once by an intense carmine color of the sulphuric acid. If the temperature is raised to the boiling point of sulphuric acid, the dissolved tellurium is first oxidized; the red color of the acid yields to a muddy-green of the dissolved selenium; the cooled solution does not now become black from tellurium, but weak yellowish-red from separated selenium, which, if only traces of it are present, is most clearly recognized by looking from above into the mouth of the test-tube held above white paper. Since commercial sulphuric acid often contains traces of selenium, it is advisable to render certain its absence from the acid to be used by means of a test experiment.

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* Pieces of a thin, chemical flask are also best for use in this case.

The antimony of the blättererz can be recognized by the method given in the previous example. In order to detect the lead and gold, a test-specimen is reduced on a charcoal rod, and the lead, containing the gold, is rinsed upon a flat piece of glass, and the dried metallic spangles are treated with moderately concentrated nitric acid as long as any portion dissolves. The acid is then evaporated, and the residue dissolved in a few milligrammes of water. The solution, placed by means of a capillary pipette upon another capsule, gives the characteristic precipitate of sulphate of lead, when treated with a few milligrammes of sulphuric acid. The gold, which separates upon solution of the lead as a brown powder, is thoroughly washed, by repeatedly pouring water upon it and taking it up again with a pipette. A portion of the dried particles of gold is fused on a charcoal rod with carbonate of soda, and obtained as gold-lustred spangles upon trituration in an agate mortar. The other portion is tested with hydrochloric acid, in which it is insoluble, is dissolved by addition of nitric acid, and after evaporation is tested for gold by proto-chloride of tin. A centigramme of the test-specimen, containing only a few tenths of a milligramme of gold, is sufficient in experienced hands for all these reactions.

## VOLATILE ELEMENTS, SEPARABLE BY

| | Metallic Incrustation and Coating. | Oxide Incrustation and Coating. | Oxide Incrustation with SnCl. | Oxide Incrustation with Sn Cl and Na O, HO. | Oxide Incrustation with Ag O, $NO_5$ and $NH_3$. |
|---|---|---|---|---|---|
| Te, | Black, with brown coating. | White. | Black. | Black. | White into yellowish. |
| Se, | Cherry red, with brick-red coating. | White. | Brick-red. | Black. | White. |
| Sb, | Black, with brown coating. | White. | White. | White. | Black; insoluble in $NH_3$ |
| As, | Black, with brown coating. | White. | White. | White. | Lemon - yellow or brownish-red; soluble in $NH_3$ |
| Bi, | Black, with soot-brown coating. | Yellowish-white. | White. | Black. | White. |
| Hg, | Gray, incoherent coating. | | | | |
| Tl, | Black, with brown coating. | White. | White. | White. | White. |
| Pb, | Black, with brown coating. | Bright ochre-yellow. | White. | White. | White. |
| Cd, | Black, with brown coating. | Black into brown, with white coating. | White. | White. | White coating, becomes blue-black. |
| Zn, | Black, with brown coating. | White. | White. | White. | White. |
| Sn, | Black, with brown coating. | Yellowish-white. | White. | White. | White. |

## REDUCTION AS INCRUSTATIONS

| Iodide Incrustation and Coating. | Iodide Incrustation with $NH_3$ (blown upon it.) | Sulphide Incrustation and Coating. | Sulphide Incrustation with $NH_4S$ | |
|---|---|---|---|---|
| Brown, breathed upon disappears transitorily. | Disappears permanently. | Black to blackish brown. | Disappears transitorily. | |
| Brown, breathed upon does not wholly disappear. | Does not disappear | Yellow to orange. | Orange, then disappears transitorily | Substances the metallic incrustations of which are scarcely soluble in dilute nitric acid. |
| Orange-red, breathed upon disappears transitorily through yellow. | Disappears permanently | Orange | Disappears transitorily | |
| Egg-yellow, breathed upon disappears transitorily. | Disappears permanently | Lemon yellow | Disappears transitorily. | |
| Bluish brown, with flesh to aurora-red coating. breathed upon disappears transitorily. | Aurora-red to egg yellow, chestnut brown when blown dry | Umber brown, with coffee-brown coating | Does not disappear. | |
| Carmine and lemon-yellow, breathed upon does not disappear. | Disappears transitorily. | Black. | Does not disappear. | Substances the metallic incrustations of which are difficultly soluble in dilute nitric acid |
| Lemon-yellow, breathed upon does not disappear. | Does not disappear | Black, with bluish gray coating. | Does not disappear | |
| Egg-yellow to lemon yellow, breathed upon does not disappear. | Disappears transitorily | Through brownish red into black. | Does not disappear | |
| White. | White. | Lemon yellow | Does not disappear. | Substances the metallic incrustations of which are instantly soluble in dilute nitric acid. |
| White. | White. | White. | Does not disappear | |
| Yellowish-white. | Yellowish-white. | White. | Does not disappear | |

# PATENTING A PRINCIPLE.

(Continued from page 340.)

The minority put a different construction upon the grant. They held that it appropriated the newly discovered property of lead, and that the plaintiff had a right to so appropriate it, and ought to recover. Lord Hope's views were greatly relied upon, and it was evidently supposed that they had been sanctioned by the House of Lords. It should be observed, further, in order that the bearing of this case may be fully understood, that, in O'Reilly *v.* Morse (which was decided the next year), Chief Justice Taney said that it was held by the court in Le Roy *v.* Tatham, that the plaintiff "was not entitled to a patent for this newly discovered principle, or quality, in lead, and that such a discovery was not patentable:" p. 117. It would seem, therefore, that the doctrine of the minority on this point was not acquiesced in by their colleagues, though it was passed over in the opinion given for the majority.

The patent came under the consideration of the court again in the case of Le Roy *v.* Tatham, 22 How. 132, and was sustained in consequence of a new view which was taken of it. In delivering the opinion of the court, Judge McLean took occasion to declare, in emphatic terms, that Lord Hope's doctrine was not law in this country.

In O'Reilly *v.* Morse, the principal question rose upon the eighth claim in the patentee's specification. It was expressed in these words, viz: "The use of the motive power of the electric, or galvanic current, however developed, for making or printing intelligible characters, signs, or letters, at any distance." The patentee did not pretend to have been the first one who had discovered that the electric current would produce motion at a distance. But he did claim, and truly, to have contrived a mechanism, or process, whereby it could be made to print characters at a distance. He set up a claim, therefore, to the exclusive right of doing this by any process or machinery whatever. This claim the court negatived in the most unequivocal terms, and Chief Justice Taney, in delivering their judgment, used this language, which will bear repetition: "Whoever discovers that a certain useful result will be produced in any art, machine, manufacture, or composition of matter by the use of certain means, is entitled to a patent for it, provided he specifies the means he uses in a manner so full and exact that any one skilled in the science to which it appertains can, by using the means he specifies, without any addition to, or subtraction from them, produce precisely the result he describes. And if this cannot be done by the means he describes, the patent is void; and if it can be done, then the patent confers on him the exclusive right to use the means he specifies to produce the result or effect he describes, and nothing more. And it makes no difference, in this respect, whether the effect is produced by chemical agency or combination, or by the application of discoveries or principles in natural philosophy, known or unknown before his invention, or by machinery acting altogether on mechanical principles. In either case he must describe the manner or process as above mentioned, and the end it accomplishes. And any one may lawfully accomplish the same end, without infringing the patent, if he uses means substantially different from those described:" p. 119. And he also declared that the doctrine of Lord Hope is not law in this country.

After the elaborate discussion and full consideration which these cases underwent in the Supreme Court, it can hardly be required to examine at length those in which the subject has been touched upon in the Circuit Courts. What was said in substance respecting them by Taney, C. J., in O'Reilly *v.* Morse, will answer the purpose. The earlier decisions are in uniform accordance with the ruling in that case, and the idea of patenting a principle is never mentioned but to be denounced. (See Evans *v.* Eaton, Pet. C. C. 341; Stone *v.* Sprague, 1 Story, 272; Wyeth *v.* Stone, Id. 285; Blanchard *v.* Sprague, 2 Id. 166, 170; 3 Sumn. 536, 540; American Pin Co. *v.* Oakville Pin Co., 3 Am. Law Reg. O. S. 137, and Law's Dig. 260); Smith *v.* Downing, Law's Dig. 593. A change was undoubtedly produced by the proceedings upon Neilson's patent, and the instructions of Lord Hope were in several instances adopted as the law by the judges in their circuits. Parker *v.* Hulme, 7 West. Law J. 419, Law's Dig. 593, and Foote *v.* Silsby, 2 Blatchf. 265, may be mentioned among them. It is a grave mistake, however, to assert that the decision upon this question in the last case was affirmed in the Supreme Court. The question arose upon the first claim alone in the plaintiff's patent; and on the hearing in the Supreme Court it was expressly stated by the learned judge, Nelson, who pronounced the decision, that the first claim was found to have been anticipated, and was not before the court: Silsby *v.* Foote, 20 How. 378.

Since O'Reilly *v.* Morse was decided, the right to patent a principle has never received the slightest countenance from the bench, but, whenever it has been adverted to, it has been denied in unqualified terms. It was so in Le Roy *v.* Tatham, 22 How. 132. In Wintermute *v.* Redington (U. S. Cir. Ct. N. D. Ohio, 1856), a patent was tried which eminently deserved all the favor to which the discovery of a new and valuable law of physics could entitle it, it being for the well-known reaction water-wheel. Yet the learned judge, WILSON, who presided at the trial, used the following language respecting it: "If the defendant, in the use of a reaction water-wheel, whether on a vertical or horizontal shaft, whether single or in pairs, has run, or caused it to be run by the aid of the vertical motion of the water upon the wheel in its line of motion, he has violated the patent; *provided he has used, in so doing, any or all of the patentee's mechanical means for producing that vertical motion, or mechanical equivalents for all or any of them to produce it.*"

We may now recur to the cases which are usually referred to in discussing this branch of the law, and which have been passed over. It will be found, on examination, that they, every one of them, involved an invention consisting exclusively in the new application of some law of mechanics, or what is equivalent to such a law. And what were held to be infringements consisted in the employment of what were mere mechanical substitutes for the devices which the patentee had described in his specification. They were neither more or less than equivalents for those devices, at least they were so regarded by the court. It is true that the judges frequently speak of the principle of the patented structure, and vindicate the patentee's exclusive right to it. But the term principle is used by them in a qualified sense. As Judge STORY said in Barrett *v.* Hall, "care should be taken to distinguish what is meant by a principle. In the minds of some men, a principle means an elementary truth or power," &c. "No one, however, in the least acquainted with law, would for a moment contend that a principle in this sense is the subject of patent." "The true legal meaning of the principle of a machine, with reference to the Patent Act, is the peculiar structure or constituent parts of such machine:" 1 Mass. 470. So it was said also by Judge McLEAN in Brooks *v.* Jenkins, "The word principle is not used here in its general signification, but as applied to the structure of a machine. It means the operative cause by which a certain effect is produced:" 3 McLEAN, 451. Or, as Judge

STORY defined it on another occasion, it means "the *modus operandi*, the peculiar manner or device of producing any given effect." Whittemore *v.* Cutter, 1 Gall. 480. When, therefore, we find it announced from the bench that the patentee, having shown one way in which this principle of his machine is made to work effectively, is entitled to the use of all other ways in which it may be utilized for that purpose, we spprehend that nothing more is intended than that his patent shall not be evaded by what are only equivalents for the mechanisms he employed.

In Jupe *v.* Pratt, 1 W. P. C. 145, for instance, there can be no pretence that the plaintiff had found out any new property of matter, any law of physics, or even any new principle of mechanics. He had, at the most, made an ingenious and novel application of well-known mathematical truths. This enables us to understand the just import of the language used by Baron ALDERSON on that occasion, which has been so often quoted. He first denied explicitly that a patent can be taken out for a principle. He adds, however, "You may take out a patent for a principle, coupled with the mode of carrying that principle into effect, provided you have not only discovered the principle, but invented some mode of carrying it into effect. But then you must start with some mode of carrying it into effect; if you have done that, then you are entitled to protect yourself from all other modes of carrying the same principles into effect, that being treated by the jury as piracy of your original invention." Now, if the learned judge intended by principle any law of nature, then his remarks were entirely foreign to the case. The plaintiff had made no such discovery, and, if he had, his discovery of it would have given him no property in what he discovered. But, if his lordship is understood to be speaking of what has been sometimes called the *modus operandi* of the invention, he is intelligible and consistent, and in harmony with what has been advanced above. The patentee of such an invention must have originated the principle in that sense. And having originated it, and described one method of applying it, he is entitled to all other methods of applying it. For all other methods of applying such a principle can be nothing more or less than substituting some equivalent or other for the mechanical device or devices which are embodied in the method he has described.

So of Crossley *v.* Beverley, 1 W. P. C. 106, 3 C. & P. 513. The operation of the machine, for which the plaintiff had a patent, depended upon a well-know law of hydrostatics, the tendency of water to rise to the same level, wherever different bodies of it are in free communication. A great deal was said about the principle of the machine, the experts testifying that after the principle was once discovered, there were a hundred ways of reducing it to practice. Now they could not be speaking of the law of hydrostatics, which has been known from time immemorial. They evidently meant the *modus operandi*, the principle of mechanism by which that law was made to contribute to the purpose of the machine. The defendant's machine was wholly unlike the plaintiff's in appearance, and even in construction. But it was shown to operate upon the same principle, and so was held to be an infringement. Not because he availed himself of the same law of hydrostatics—everybody might make use of that. But he employed the same mechanical principle of operation. In other words, his devices were mere mechanical equivalents for those which were described in the plaintiff's patent.

Again, in Walton *v.* Potter, 1 W. P. C. 585, 3 M. & G. 411, 3 Scott N. R. 91, the patentee had made no discovery of any law of physics. He had merely made an ingenious application of the well-known qualities of India rubber, in order to hold the teeth of wool-cards in a suitable position, yet have them flexible. He used for this purpose a sheet of the gum between two layers of cloth. The defendant used cloth enveloped in the gum, by having been dipped in a solution of it and dried, and thus effected the same object: and he was held to have infringed the patent. Why? Because he used India rubber? No; but his fabric operated on the same principle; that is, the same principle of mechanics; and was a mere substitute for that of the plaintiffs'.

We have seen that the plaintiffs' patent in Neilson *v.* Harford, was construed to cover the process of heating the air in a vessel placed between the blowing apparatus and the furnace. The defendant used a vessel in that position for the same purpose; but the construction of it was entirely different from that of the plaintiffs'. It was held, nevertheless, to be an infringement. It performed the same functions, more effectually it is true, but still the same. In a mechanical point of view it operated on the same principle, and was its counterpart.

(To be continued.)

# EDUCATIONAL

## CHEMICAL EXPERIMENTS FOR THE LECTURE-TABLE.

BY PROF. ALBERT R. LEEDS.

*Exhibitions with the Lantern of the Reactions of Gases upon Solutions.* The tank employed for these experiments is preferably of the kind figured by Prof. Morton, in the October No., 1867, p. 281, of the *Journal.* Its especial advantage is the rapidity with which it may be taken apart and cleansed. The best form of generator for obtaining the supply of gases is that which is customarily employed for the evolution of small quantities of sulphuretted hydrogen. It is a small bulb of thin German glass, which is provided with a wide neck for the introduction of materials, and a small tube entering the first at right angles, and bent downwards in order to carry the gases into the liquids to be tested. It is well to break the exit tube at the bend, and then to connect the broken parts again by India-rubber tubing. This prevents awkward accidents on future occasions, and much facilitates the introduction and withdrawal of the exit tube from the tank.

If a small quantity of black oxide of manganese and hydrochloric acid be placed in the generator, there will be a slow evolution of chlorine in the cold—quite rapid enough, however, for many experiments—and a copious supply when the flask is gently heated. If this gas be passed into a dilute solution of potassic iodide and starch, the iodide of potassium will be decomposed, and its liberated iodine, coming into contact with the starch, will form a cloud of dark-blue iodide of starch with each successive bubble of chlorine. So if a drop of mercury be poured into the generator, and a drachm of nitric acid added, the liberated gas will decompose the potassic iodide in like manner, and the production of the starch iodide will be shown by the rays passing from the lime-light through the tank and falling upon the screen. If the tank be filled with colored liquids formed by adding solutions of litmus, logwood, cochineal, sulphate of indigo, the various analine dyes, ink, &c., to clear water, and bubbles of chlorine be passed in, a few seconds in each case will be sufficient to show the bleaching action of the gas, and the light will break through where the gas is entering, and gradually spread over the screen until the india-rubber walls of the tank become discernible.

Or if a solution of iodide of potassium and common sulphuric ether be employed, and chlorine passed through the liquid, the liberated iodine will dissolve in the ether and form a dark-brown superstratum; this experiment is of a very striking character. A similar result will be obtained with bromide of potassium and ether.

When to a small amount of mercury a quantity of sulphuric acid is added in the flask, and strongly heated, a large amount of sulphurous acid is disengaged, which exerts upon different coloring substances its well-known bleaching action. The purple color of litmus is speedily changed to red, but the decoloration does not proceed to such a point as to prove satisfactory in these experiments. The same remark applies, in a greater or less degree, to the other dye-stuffs: chlorine is much more satisfactory. Passed into a solution of chloride of barium, the sulphurous acid-gas (owing, of course, to the presence of small quantities of sulphuric acid,) produces a precipitate of sulphate of baryta. It is better to add the chloride of barium to a colorless solution of sulphurous acid in water, which has been previously placed in the tank, and afterwards pass in the gas evolved from the action of nitric acid upon charcoal, mercury, copper, &c. The oxidation of the sulphurous to sulphuric acid by the hyponitric acid bubbles, is immediately evinced by an abundant precipitate of barytic sulphate. This is an elegant preliminary experiment to the lecture-room demonstration of the commercial mode of manufacturing sulphuric acid.

Another interesting series of experiments may be performed in the same manner, upon the qualitative analysis, by means of sulphuretted hydrogen gas of solutions of the various common and noble metals. Sulphide of antimony and hydrochloric acid are to be preferred to sulphate of iron and dilute oil of vitriol for the production of the gas. On applying a very moderate heat, the sulphuretted hydrogen bubbles rapidly through the liquid in the tank. If the latter contain a dilute acid solution of persulphate of iron, there is a clouding up of the screen, from the separation of sulphur. In an acid solution of nitrate of cadmium, arsenious acid or bichloride of tin, a precipitate of the yellow sulphide of cadmium, orpiment or aurum musivum become apparent. Passed through a dilute solution of terchloride of antimony, the gas produces an orange-colored precipitate of tersulphide of antimony visible upon the screen; and through protochloride of tin, a dark-brownish red cloudiness of protosulphide of tin. Still more striking than the former are the brownish-black, or, as seen by transmitted light upon the screen, the dense black clouds of the protosulphides of lead, copper, bismuth, the bisulphide of platinum, and the tersulphides of bismuth and gold, which are formed when the hydrosulphuric acid is made to bubble through dilute acid solutions of any of the soluble salts of these elements.

The precipitation of the carbonates of lime, baryta, strontia, lead, &c., may likewise be shown upon the screen, by passing carbonic acid from the usual carbonic acid generator into aqueous solutions of the hydrates of these alkalies, or into the basic acetate (called, in the Pharmacopaea, Goulard's Extract,) of lead, &c. The last named experiment is particularly useful in the explanation of the French method of Ceruse manufacture. The presence of carbonic acid in the breath may, likewise, be pleasingly exhibited by passing the expired air through a glass tube into lime-water, or, what is much more delicate, a solution of basic acetate of lead in rain or diluted water in the tank.

Finally, to exhibit the action of ammonia, the small gas-generator, mentioned at the beginning of the article, should be about half filled with a mechanical mixture of equal parts of powdered caustic potash or quicklime, with sal-ammoniac. When the ammoniacal gas, evolved on heating, is passed through a solution of alum or other salt of alumina, a precipitate of hydrate of alumina is rendered evident. In a solution of oxide of zinc, provided free acid be not present in excess, the gas forms a precipitate of hydrated oxide of zinc, which dissolves in an excess of the zinc solution. With a solution of protochloride or sulphate of manganese, the ammonia forms a whitish-gray precipitate of hydrated protoxide of manganese, rapidly altering to a dark brown by exposure to the air. In a solution of sulphate of nickel, the gas produces a green cloudiness, dissolving on a continued addition of ammonia, to a blue liquid, containing a compound of protoxide of nickel and ammonia (Fresenius). In chloride or nitrate of cobalt, a blue precipitate, altering to green, is first formed, and afterwards dissolved by an excess of the gas to a greenish-brown(?)—reddish-brown, (Fresenius)—fluid. From a solution of protochloride or protosulphate of iron, the ammonia separates a white precipitate of hydrate of protoxide, rapidly changing to green and reddish-brown, from the persulphate a precipitate of the sesquioxide of iron. A few bubbles of ammonia passed into nitrate of silver, produce a grayish-white (?)—brown, fresenius—precipitate of oxide of silver, disappearing as a further supply of the gas enters. In the basic acetate of lead, there is an immediate white precipitate. So from the solutions of corrosive sublimate, nitrate of cadmium, protochloride of tin and terchloride of antimony, the introduction of the ammoniacal gas is followed by the formation of white precipitates. In a concentrated solution of terchloride of gold, there is an immediate deposition of reddish aurate of ammonia (fulminating gold). In a solution of sulphate or other salt of copper, the first portion of ammoniacal gas introduced gives rise to a greenish-blue precipitate of a basic salt of copper, dissolving on a further involution of the gas, to an azure-blue basic double salt of ammonio-oxide of copper (fresenius). The delicacy of Nessler's test may form an interesting conclusion to these experiments with ammonia. The test liquid is prepared by dissolving a small quantity of potassic iodide in water, heating the solution, and adding mercuric iodide until the portion last added remains undissolved. The mixture, after considerable dilution, is mixed with a somewhat greater quantity of a concentrated solution of potassic hydrate. If the latter gives rise to turbidity, the solution is to be filtered again. The first few bubbles of ammoniacal gas produce a copious reddish-brown precipitate.

*To Render Carbonic Acid Gas Visible.* When a generator of carbonic acid gas is placed in front of a screen illuminated with the magic lantern, and separated from the former by an interval of about six feet, the stream of gas issuing from an exit tube of the generator becomes evident as a series of wavy descending lines upon the screen. A candle, placed at the bottom of a tall jar, produces an ascending current, and this, together with the extinction of the light by falling carbonic acid, may be projected upon the screen by rays from the lantern. In like manner, a current of carbonic acid gas, or of ether vapor, issuing from the longer limb of a syphon, when the gas in both the upper and lower vessels has previously been invisible, may be made evident to the eye. The convection of air, when a hot iron ball is placed in front of a screen, is a pleasing experiment of a similar description.

*Reduction of Metallic Oxides by Means of Burning Gas.* It will be found, by those who have the opportunity of using ordinary burning gas, that it may be employed to illustrate the subject of reduction, by passing a stream of the gas over an oxide, such as the red oxides of mercury and lead, strongly heated in the bulb of a reduction tube. The sides of the tube become covered with moisture, and after a time globules of mercury collect, and, by tilting the tube, may be made to run out. The temperature required is much lower than that which is essential to direct decomposition. A pleasing method of showing the reduction of oxide of lead by another method—with charcoal—may be performed in the following manner: pulverize together, in a tin tray, an excess of charcoal with some potassic chlorate and plumbic oxide. Upon applying a match to the mixture, beautiful clouds of oxide of lead are given off; and, if a large bell-jar be inverted over them, they will form a yellow sublimate upon its inner surface. Some of the plumbic oxide is reduced by the charcoal to the metallic state, as will be perceived upon pulverizing the residue with a spatula, and washing with water, when the light particles of carbon will be carried off, and metallic lead remain behind. Throw the latter upon an anvil, and strike with the hammer, when a disc of metallic lead will be obtained.

*Portable Magic Lantern.* With the aid of the magnesium lamp and the portable lantern described below, together with a few chemicals, diagrams, views, and a few simple pieces of apparatus, one may carry a course of brilliant, popular lectures along with him in a portmanteau. There is a rectangular frame of walnut, or other strong wood, seven inches broad and twelve long, provided with a groove on its upper surface, which serves as a base for the magnesium lamp, and permits it to be run backward and forward until it is accurately focussed. A similar second frame, six inches long, is fastened to the first at one end, by means of hinges placed on the lower side, and a hook upon the upper side. When the latter is fastened, the base is thus lengthened out to eighteen inches. Attached to the anterior end of the first described half of the base, there is an upright of wood, which carries the condenser. The cell of the condenser projects on the posterior face of the upright, and there are hinges placed at the bottom and back of this upright, so that when folded backward the condenser may drop into the open space left by the sides of the frame. A hook and staple on the front side which fastens this upright to the second half of the base, preserves all parts in position. The upright for the objective tube is also provided with a hook and hinges, and folds upon its portion of the base in a similar manner. When not in use, the tube of the objective, which should be arranged so as to slip into a cell, and thus admit of ready attachment and removal, may be packed away in the space left by the condenser in the frame of the base. When not in use, the lantern has the appearance of four pieces of wood.

(To be continued.)

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## THE MAGIC LANTERN AS A MEANS OF DEMONSTRATION.

(Continued from page 347.)

### LANTERN PICTURES.

AFTER all that has been published in photographic journals on the subject, it would be at least tiresome here, to say anything about the best modes of making photographic transparencies. We will only advise those using such pictures, in all cases if possible, to try in the lantern before purchasing, as without long practice and much care, one is easily deceived and may select as an admirable picture, one which in use is most unsatisfactory.

The use of photographs from engravings and woodcuts, in connection with the thorough study of various branches, such as is or ought to be pursued in colleges and schools, open to the teacher a wide field for the illustration of his subject, by which the interest and instructiveness of his course may be largely extended. With a good lantern and screen, enough diffused light from an open window or gas burner may be admitted, to give every facility to the class for taking notes, while the pictures illustrating the subject, are yet clearly defined upon the screen.

We speak here from experience, having employed this plan during the past winter, at the University of Pennsylvania, with entire success. In this case, perfect transparency of the film in all *white* parts of the picture, combined with great opacity in the dark lines, is of paramount importance, and in this connection we can speak most highly of the very numerous specimens furnished us by O. H. Willard (often made at an hour's notice, the same day that they were first used), which leave nothing to be desired in both these respects.

In many cases, however, it becomes desirable to prepare some simple drawing or diagram, which would not seem worth the time and cost of photographing.

Several courses then present themselves.

1st. We may prepare a glass plate by flowing it with collodion, sensitizing in the silver bath, exposing to bright sunlight, and developing, and then draw with a sharp steel point the desired figures.

This drawing may be done in the lantern, as suggested by my friend, Prof. Leeds, with very excellent effect.

The advantages and drawbacks of this plan under various conditions, are manifest without enumeration.

2d. We may draw on glass directly with India ink, using both brush and pen, as described in this *Journal* some time since, in connection with pictures of sun-spots thus prepared and exhibited at one of the meetings of the Institute. The plan to be adopted is as follows: The glass plate to be employed, should be thoroughly cleaned and rubbed with paper moistened with a drop of alcohol. The India ink employed should be of that kind known as Japanese, which will not soak out in water, but requires to be rubbed on a slab or plate (for which a piece of ground glass is the best material), and which is of rather a greasy than aqueous character. If lines only are to be produced, the ink should be made as thick as possible, short of preventing it from flowing from the pen. Perfectly sharp lines can then be produced with certainty, and no risk of blotting or running out upon the glass. If circles are to be struck, a fragment of paper may be pasted at the centre, to serve as a support to the stationary point of the compass, and scratched off after the drawing of these parts is finished. A strip of card held firmly at one end, will also answer where an entire circle is not required. Where half tones are required, these should, if possible, be put in first with thin color, and rather too dark than too light. Then with a needle mounted in a stick or fine point of compasses, the shade may be lightened by stippling, or a series of light blows, producing dots of light in the shade, or by fine circular lines or circles intersecting and crossing each other in every direction. Lastly, with a stiff brush cut off short and lightly applied, first to some thick ink and then to the glass, black stippling may be easily and rapidly applied.

These are the only precautions, beside patience and practice, that need be here recommended.

3d. We may draw or trace with India ink on the thin white or colorless sheet gelatine, used by engravers, and then enclose the sheet between glass plates. This plan I first employed some days since, when my assistant, Mr. Alex. Outerbridge, Jr., suggested that woodcuts and lithographs might be printed off on this same material, from the blocks or stones, and employed in like manner.

This plan on trial, proved perfectly feasible, and has been of the greatest use in various connections. It promises, in fact, to open a vast field to the lantern system of illustration, for the cost of reproduction of any existing woodcut or lithographic drawing, for this purpose, is thus rendered insignificant.

Mr. Outerbridge has also succeeded in preparing sheets of gelatine of the most excellent character, for this purpose. An account of the process by which they are made will be found at page 300 of this *Journal.*

With regard to the coloring of photographs or other transparencies, we know very little, and wish very much that some one practically conversant with the matter would place some of his information before the public.

For mere purposes of indication, common water colors, varnished when dry, will be of use, and of course, colors ground in drying oil or varnish, will answer better yet, where the work required is of sufficient extent to repay for the time expended in their preparation. The best effects, however, are reached by flowing the plate with albumen, and painting with aniline colors.

(To be continued.)

## ABSORPTION OF GASES BY CHARCOAL.

By Professor Albert R. Leeds.

In Watts' excellent Dictionary of Chemistry, Vol. 1, p. 761, there is an account of the absorptive power of charcoal upon gases, which has been taken chiefly from the late researches of Dr. Stenhouse. Having repeated and somewhat extended these experiments, I have thought that so much as follows may be of general interest.

Some pieces of charcoal prepared from a cocoa-nut shell, and which were of a dense, lustrous character, were placed in a tube, and a stream of sulphuretted hydrogen, previously dried with chloride of calcium, passed over them. After the lapse of ten minutes, the tube was detached, and indicated on the balance an increase of weight, due to the absorbed gas. A current of oxygen was next passed over the charcoal; the tube became slightly warm, owing to the oxidation of the hydrosulphuric acid, but in no case, in a number of experiments, was there (as I have seen it stated), a spontaneous ignition. On heating with a spirit-lamp, vapor of water was condensed upon the sides of the tube, and sulphur deposited; sulphurous acid not perceptible. When platinized was substituted for ordinary charcoal, the amount of moisture and sulphur was increased. Even in this instance, however, ignition was not spontaneous, but followed on the application of the spirit-lamp for a few moments.

By depositing finely divided platinum upon the surface and in the pores of the charcoal, a variety of interesting results were obtained. This may be effected by boiling charcoal in lumps or powder in a solution of bichloride of platinum for five to fifteen minutes, according to the size of the pieces, and then heating the charcoal to redness in a platinum crucible; holding the charcoal in the flame of a spirit-lamp will answer. A piece platinized in this way was immersed in a jar, containing one measure of oxygen, and two of hydrogen; the charcoal glowed with a dull red light, and effected a silent combination of the mixed gases. A more highly platinized fragment lit up instantaneously, the jar became clouded with smoke, and union was determined with explosion. In a stream of hydrogen, the platinized charcoal, which was previously at the temperature of the room, ignited quickly throughout and set fire to the gas. In oxygen, no action apparent. Held before the nozzle of the compound blow-pipe, the jet was speedily lighted. When previously warmed, the platinized charcoal became incandescent in burning gas, but did not inflame it, owing to the high temperature at which coal gas ignites. In alcohol vapor, there was no action apparent in the cold, but a spark previously formed in the flame of a lamp, increased in size with the production of acid vapors. A mixture of one volume of hydrogen and one of chlorine was not ignited; whether hydrochloric acid was silently formed at a slow rate was not determined. The importance of such experiments in relation to ventilation and disinfecting will be readily perceived.

# Franklin Institute.

### Proceedings of the Stated Monthly Meeting, April 22d, 1868.

THE meeting was called to order with the Vice-President, Mr. Coleman Sellers, in the Chair.

The minutes of the last meeting were read and approved.

The Actuary submitted the minutes of the Board of Managers, and reported that, at their stated meeting held April 8th, inst., donations to the Library were received from the Royal Astronomical Society and the Society of Arts, London, and the Association for the Prevention of Steam Boiler Explosions, Manchester, England; la Société Industrielle, Mulhouse, and Thomas W. Evans, Esq., Paris, France; the Canadian Government, Ottawa, Canada; P. W. Sheafer, Pottsville, Penna.; Messrs. Henry R. Campbell, John Clayton, B. Henry Bartol, and the Mercantile Library Company of Philadelphia.

Also, that the following resolutions were passed:

*Resolved*, That it is expedient to postpone the exhibition intended to be held this year.

*Resolved*, That the Committee on Exhibition in 1868 be continued, and that their report, with proposed plan of organization, be referred back to them for further action.

The various Standing Committees reported their minutes. And the Special Committee appointed to prepare resolutions on the death of Sir David Brewster, reported that they would present to the Institute the following resolutions for their action:

*Resolved*, That in the death of Sir David Brewster, a serious loss has been sustained by the world of science, not only by reason of the vast store of information and skill thus removed from among the laborers in her fields, but also by reason of the interruption of studies and investigations tending to throw light upon many obscure subjects in the direction of optical research.

*Resolved*, That in the death of Sir David Brewster, the world at large has lost one of those who have contributed, by their labors, in a marked degree, not only to the progress of science, but also to the general diffusion of information and the development of a taste for the refining and cultivating study of the physical sciences.

*Resolved*, That a copy of the above resolutions be transmitted to the family of the deceased.

A paper, by Mr. Charles H. Rockwell, on the Suez Canal was then read by the Secretary, and the thanks of the Institute were tendered to Mr. Rockwell.

Prof. Rogers gave a short history of Electro-Magnetism and its connection with Magneto-Electricity, and explained one of Wilde's New Magneto-Electrical Machines as improved and made by Ladd, of London. Some ingenious French Syphon Filters were also exhibited by the same gentleman.

The Secretary's report was then read. After which, the meeting was, on motion, adjourned. HENRY MORTON, *Secretary.*

# Bibliographical Notice.

*The Workshop.* A monthly Journal devoted to the Progress of the Useful Arts. Edited by W. Baumer and I. Schnorr. E. Steiger, 17 North William Street, New York.

We have received from Mr. Steiger, several numbers of this very admirable publication. It is a large quarto pamphlet 10 by 12½ inches, with 16 pages in each number, of which 13 are devoted to illustrations in the shape of admirable wood cuts, while 3 are filled with printed matter.

The style of the work as regards artistic merit of designs and engravings, printing and paper, is admirable; as regards its scope, the following enumeration may suffice:

"This periodical is the American edition of a German monthly, '*Die Gewerbehalle*,' which has a very large circulation, and is now being published simultaneously in German, French and English.

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Comparison *of some of the Meteorological Phenomena of* April, 1868, *with those of* April, 1867, *and of the same month for* seventeen *years, at Philadelphia, Pa.* Barometer 60 feet above mean tide in the Delaware River. Latitude 39° 57½′ N.; Longitude 75° 11¼′ W. from Greenwich. By Professor J. A. Kirkpatrick, of the Central High School.

| | April, 1868. | April, 1867. | April, for 17 years. |
|---|---|---|---|
| Thermometer—Highest—degree | 70·00° | 80·00° | 88·00° |
| “ date | 1st & 23d. | 22d. | 24th, '61. |
| Warmest day—mean | 62·00 | 64·83 | 74·30 |
| “ “ date | 17th. | 22d. | 29th, '56. |
| Lowest—degree | 23·00 | 36·00 | 20·00 |
| “ date | 13th. | 28th. | 7th, '57. |
| Coldest day—mean | 32·33 | 41·50 | 27·70 |
| “ “ date | 5th. | 24th. | 2d, '57. |
| Mean daily oscillation | 16·80 | 17·75 | 16·42 |
| “ “ range | 7.73 | 6·54 | 6·32 |
| Means at 7 A. M. | 42·28 | 47·22 | 45·99 |
| “ 2 P. M. | 52·78 | 59·92 | 57·56 |
| “ 9 P. M. | 46·38 | 52·32 | 49·87 |
| “ for the month | 47·15 | 53·15 | 51·14 |
| Barometer—Highest—inches | 30·458 | 30·314 | 30·518 |
| “ date | 24th. | 14th. | 3d, '54. |
| Greatest mean daily pressure | 30·418 | 30·289 | 30·458 |
| “ “ “ date | 24th. | 14th. | 3d, '54. |
| Lowest—inches | 29·192 | 29·295 | 28·820 |
| “ date | 7th. | 22d. | 23d, '66. |
| Least mean daily pressure | 29·377 | 29·516 | 28·959 |
| “ “ “ date | 7th. | 22d. | 21st, '52. |
| Mean daily range | 0·241 | 0·234 | 0·175 |
| Means at 7 A. M | 30·035 | 29·966 | 29·842 |
| “ 2 P. M | 29·980 | 29.906 | 29·797 |
| “ 9 P. M | 29·989 | 29·931 | 29·827 |
| “ for the month | 30·001 | 29·934 | 29·822 |
| Force of Vapor—Greatest—inches | 0·528 | 0·504 | 0·689 |
| “ date | 16th. | 30th. | 29th, '65. |
| Least—inches | ·076 | ·074 | ·066 |
| “ date | 8th. | 6th. | 13th, '52. |
| Means at 7 A. M | ·202 | ·213 | ·231 |
| “ 2 P. M | ·236 | ·222 | ·249 |
| “ 9 P. M | ·242 | ·241 | ·253 |
| “ for the month | ·227 | ·225 | ·244 |
| Relative Humidity—Greatest—per cent | 94·0 | 94·0 | 100·0 |
| “ date | 12th. | 30th. | Often. |
| Least—per cent | 30·0 | 21·0 | 13·0 |
| “ date | 1st & 6th. | 6th. | 13th, '52. |
| Means at 7 A. M. | 72·2 | 63·0 | 70·6 |
| “ 2 P. M. | 56·0 | 42·6 | 51·2 |
| “ 9 P. M. | 72·1 | 59·3 | 67·2 |
| “ for the month | 66·8 | 55·0 | 63·0 |
| Clouds—Number of clear days* | 6· | 9· | 8·3 |
| “ cloudy days | 24· | 21· | 21·7 |
| Means of sky covered at 7 A. M | 61·0 per ct | 58·0 per ct | 62·6 per ct |
| “ “ “ 2 P. M | 65·7 | 57·7 | 66·2 |
| “ “ “ 9 P. M | 57·3 | 42·3 | 53·1 |
| “ “ for the month | 61·3 | 52·6 | 60·6 |
| Rain and snow—Amount—inches | 4·89 | 1·360 | 4·503 |
| No. of days on which rain or snow fell. | 13. | 10· | 12·6 |
| Prevailing Winds—Times in 1000 | s87°43′w.153 | s 80° 8′ w·143 | N70°13′w.147 |

* Sky one-third or less covered at the hours of observation.

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